Folks,

This is an electronic version of *Electronic Installation Practices Manual, Chapter 9, Cabling*, NAVSHIPS 900171, 1951 with Change 2, 23 May 1952.

Museum ships stabilizing or restoring their electrical systems will appreciate many parts of the manual. Items such as the proper ways of working with armored cable, lacing, etc. are included.

Readers of this manual will also find a *Unit Course in Marine Electricity* interesting. That manual covers WW II practice and the two manuals complement each other with more details in one or the other manuals. The Fleetsub Online, *Submarine Electrical Installations* contains information for both submarines and surface ships.

In addition to errors we have attempted to preserve from the original this text was captured by optical character recognition. This process creates errors that are compounded while encoding for the Web.

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Richard Pekelney
Webmaster

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**Search Electronic Installation Practices Manual, Chapter 9**

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NAVSHIPS 900171

# ELECTRONIC INSTALLATION PRACTICES MANUAL

## CHAPTER 9

# CABLING

BUREAU OF SHIPS NAVY DEPARTMENT

NAVSHIPS 900171

# ELECTRONIC INSTALLATION PRACTICES MANUAL
# CHAPTER 9
# CABLING

BUREAU OF SHIPS NAVY DEPARTMENT

Approved 27 June 1951
Change 1 29 October 1951
Change 2 23 May 1952

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| 9-2 | Change 2 | 9-96 | Change 1 |
| 9-3 to 9-5 | Original | 9-97 to 9-99 | Original |
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| 9-15 to 9-36 | Original | 9-101 to 9-110 | Original |
| 9-37 | Change 2 | i-1 to i-8 | Change 2 |



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# ELECTRONIC INSTALLATION
# PRACTICES MANUAL

This manual is intended for the use of the electronic installation worker. It may be used as a reference book on installation practices or in training beginners in Naval electronic installation work.

Subject matter in this text is intended as supplementary to, but not superseding existing and applicable specifications.

Appreciation is extended to the various Naval Shipyards, Commercial Firms, Service Representatives and Manufacturers who were contacted and without whose cooperation this manual would not be possible.

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SECTION 5-NUMBERING CABLES AND CONDUCTORS

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Folks,

*Unit Course in Marine Electricity*, 1942, was created during the peak of the massive shipbuilding campaign of WW II. During the war a large number of workers were trained in new trades to meet the increased demand for new labor. This was one of the courses created to prepare those new workers.

Museum ships stabilizing or restoring their electrical systems will appreciate many parts of the manual. Items such as the proper ways of working with armored cable, lacing, etc. are included.

Readers of this manual will also find a *Electronic Installation Practices Manual, Chapter 9, Cabling* interesting. That manual covers post WW II practice and the two manuals complement each other with more details in one or the other manuals. The Fleetsub Online, *Submarine Electrical Installations* contains information for both submarines and surface ships.

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**Search Unit Course in Marine Electricity**

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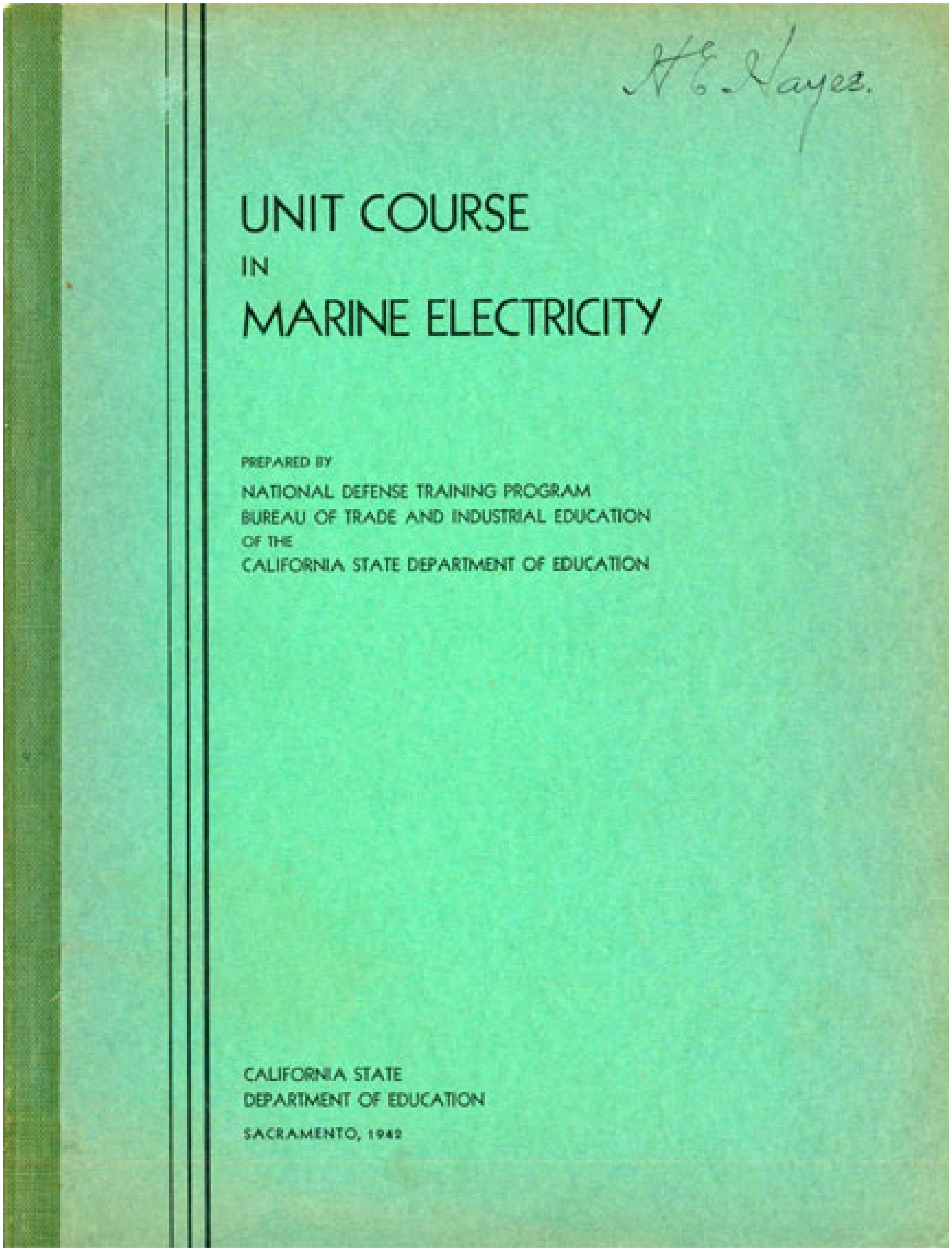


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# UNIT COURSE IN MARINE ELECTRICITY
Revised with Supplement

Prepared by
National Defense Training Program
Bureau of Trade and Industrial Education
of the
California State Department of Education

California State Department of Education
Sacramento, 1942

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H. J. Delaney, Naval Inspector



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# PREFACE

The safety of our country is dependent in large part, during this period of national emergency, upon the production of instruments of warfare that are essential to defense. The training of a great number of individuals for occupations essential to national defense is, therefore, vitally important at this particular time.

The defense training program is maintained under the provisions of Public Law No. 146 by state departments of education in co-operation with the United States Office of Education, through L. S. Hawkins, Director of Vocational Training for Defense Workers. Moneys are available to the states to train large numbers of personnel in defense occupations to meet the demands of local industries having defense contracts. Up-to-date instructional materials are necessary in order that this training may be most effective.

The California Plan of Vocational Education in and for Occupations Essential to National Defense has made provision, therefore, for the development and publication of instructional materials in defense occupations as a part of the state program.

California is actively engaged in training for shipbuilding, which is one of the most important industries in the defense program. This **Unit Course in Marine Electricity** has been developed by members of the staff of the Bureau of Trade and Industrial Education who are charged with the responsibility of preparing needed instructional materials for this program. Employees of the General Engineering and Dry Dock Company of Alameda, the Moore Dry Dock Company of Oakland, and the Todd-California Shipbuilding Corporation of Richmond acted as a committee for the development of this material. This committee received assistance and advice from H. J. Delaney, Naval Inspector, and from the Electricians Local Unions Numbers 6, 180, 302, 595, and 617 of San Francisco, Vallejo, Richmond, Oakland, and San Mateo, respectively.



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Marion A. Grosse, Special Supervisor for National Defense Training, co-ordinated the work of the committee.

The material was edited and prepared for publication by the Special Supervisor for National Defense Training in Charge of Publications, Margaret McKieneavy.

The fine co-operation of the Moore Dry Dock Company in the defense training program is appreciated.

This revised edition includes a supplement covering certain information applicable to naval practices.

J. C. BESWICK
Chief, Bureau of Trade and Industrial Education; and State Director of Vocational Training for Defense Workers



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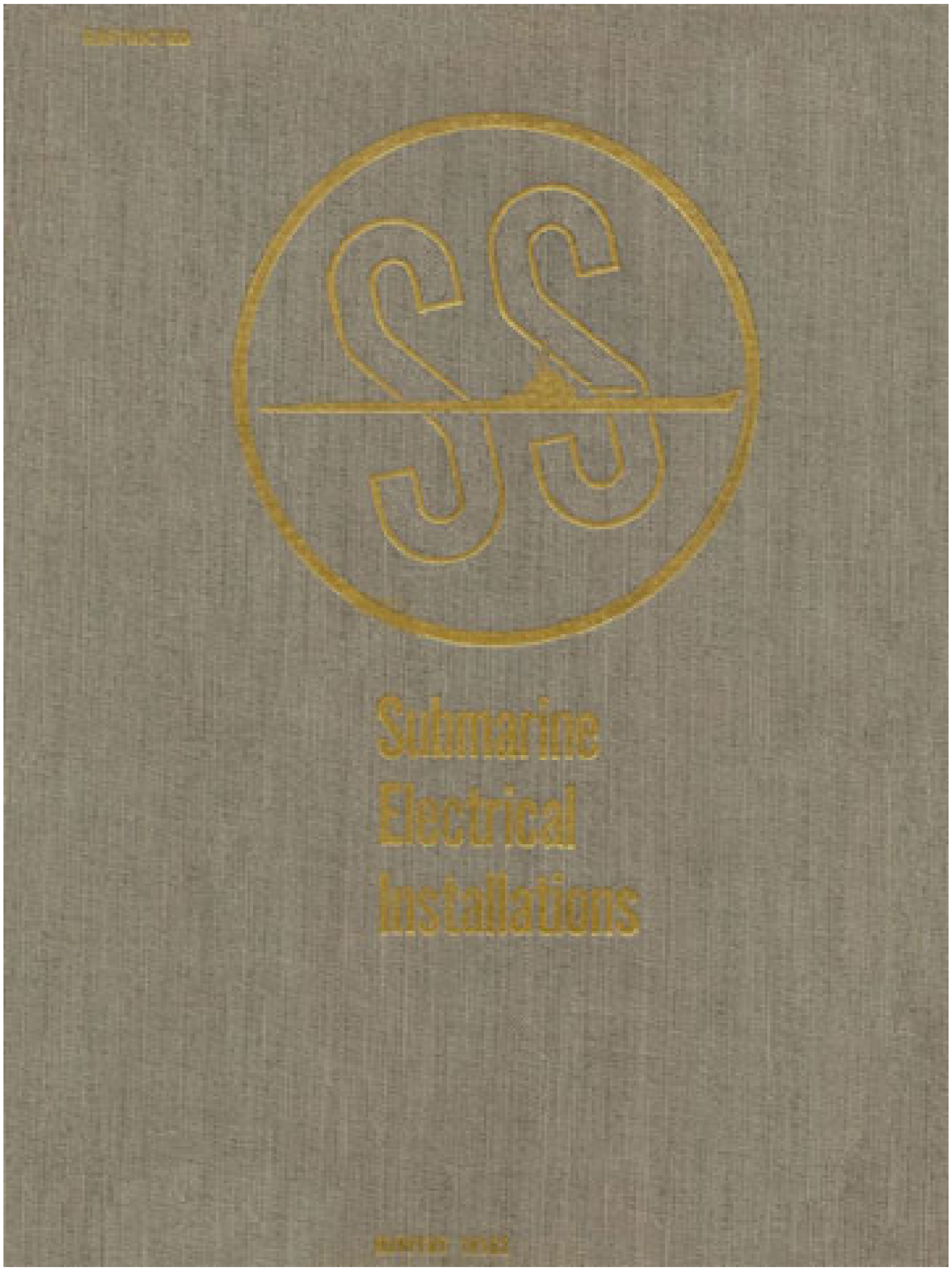
Version 1.01, 15 Jan 06

# The Fleet Type Submarine Online
# Submarine Electrical Installations



Folks,

*Submarine Electrical Installations*, Navpers 16162, is one of a series of submarine training manuals that was completed just after WW II. The series describes the peak of WW II US submarine technology.

In this online version of the manual we have attempted to keep the flavor of the original layout while taking advantage of the Web's universal accessibility. Different browsers and fonts will cause the text to move, but the text will remain roughly where it is in the original manual. In addition to errors we have attempted to preserve from the original (for example, it was CS *Hunley*, not CS *Huntley*), this text was captured by optical character recognition. This process creates errors that are compounded while encoding for the Web. Please report any typos, or particularly annoying layout issues to info@hnsa.org for correction.

Our thanks to Shelly Shelstad ( http://www.history-on-cdrom.com) for permitting us to use images he has scanned, particularly the oversized images that were meticulously pieced together. History on CD ROM sells a very nice CD version of this manual in PDF format for easy access off the web and for a printing. Thanks also to IKON Office Solutions (http://www.ikon.com) for scanning services.

Richard Pekelney
Webmaster

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NavPers 16162

Produced for ComSubLant by
Standards and Curriculum Division,
Training, Bureau of Naval Personnel

# SUBMARINE

# ELECTRICAL INSTALLATIONS

June 1946

RESTRICTED

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*This is one of a series of Submarine Training Manuals. The series includes:*

| | | |
|---|---|---|
| 1. | The Fleet Type Submarine | NavPers 16160 |
| 2. | Submarine Main Propulsion Diesels | NavPers 16161 |
| 3. | Submarine Electrical Installations | NavPers 16162 |
| 4. | Submarine Refrigerating and Air-Conditioning Systems | NavPers 16163 |
| 5. | Submarine Distilling Systems | Navpers 16163A |
| 6. | Submarine Air Systems | NavPers 16164 |
| 7. | Submarine Periscope Manual | NavPers 16165 |
| 8. | Submarine Trim and Drain Systems | NavPers 16166 |
| 9. | Submarine Sonar Operator's Manual | NavPers 16167 |
| 10. | Submarine Underwater Log Systems | NavPers 16168 |
| 11. | Submarine Hydraulic Systems | NavPers 16169 |
| 12. | Torpedo Tubes, 21-Inch submerged, Mks 32 to 39 | O.P. 1085 |



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## PREFACE

The Submarine School, Submarine Base, New London, Connecticut, and other activities of Submarines, Atlantic Fleet have collaborated in the preparation of this manual.

All submarine machinery is operated directly by electricity generated initially from energy supplied by the ship's diesel engines, or indirectly through the transmission media of high-pressure air or hydraulic systems. A thorough knowledge of the theory, operation, and maintenance of the electrical machinery is a requisite to successful operation of the submarine and the fulfillment of her mission in life-the destruction of the enemy's ships wherever and under whatever conditions they may be encountered. The accomplishment of this mission necessitates that operating personnel be trained to maintain the machinery in reliable operating condition as well as to operate it correctly.

The purpose of this manual is to acquaint the student with the theory, operation, and construction of the components of the electrical installations. Special emphasis is Oven to the more important maintenance features and methods.

A thorough knowledge of the ship and its machinery may, in an emergency, be the means of keeping it and its crew in battle condition.

The manual is intended as a primary instruction manual, ashore and afloat, for officer and enlisted personnel having duties in connection with submarine electrical installations. For details of construction and maintenance, the manufacturer's instruction books and Navy Department manuals should be consulted.

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### MAIN AND AUXILIARY POWER

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## ILLUSTRATIONS

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## ILLUSTRATIONS

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## ILLUSTRATIONS

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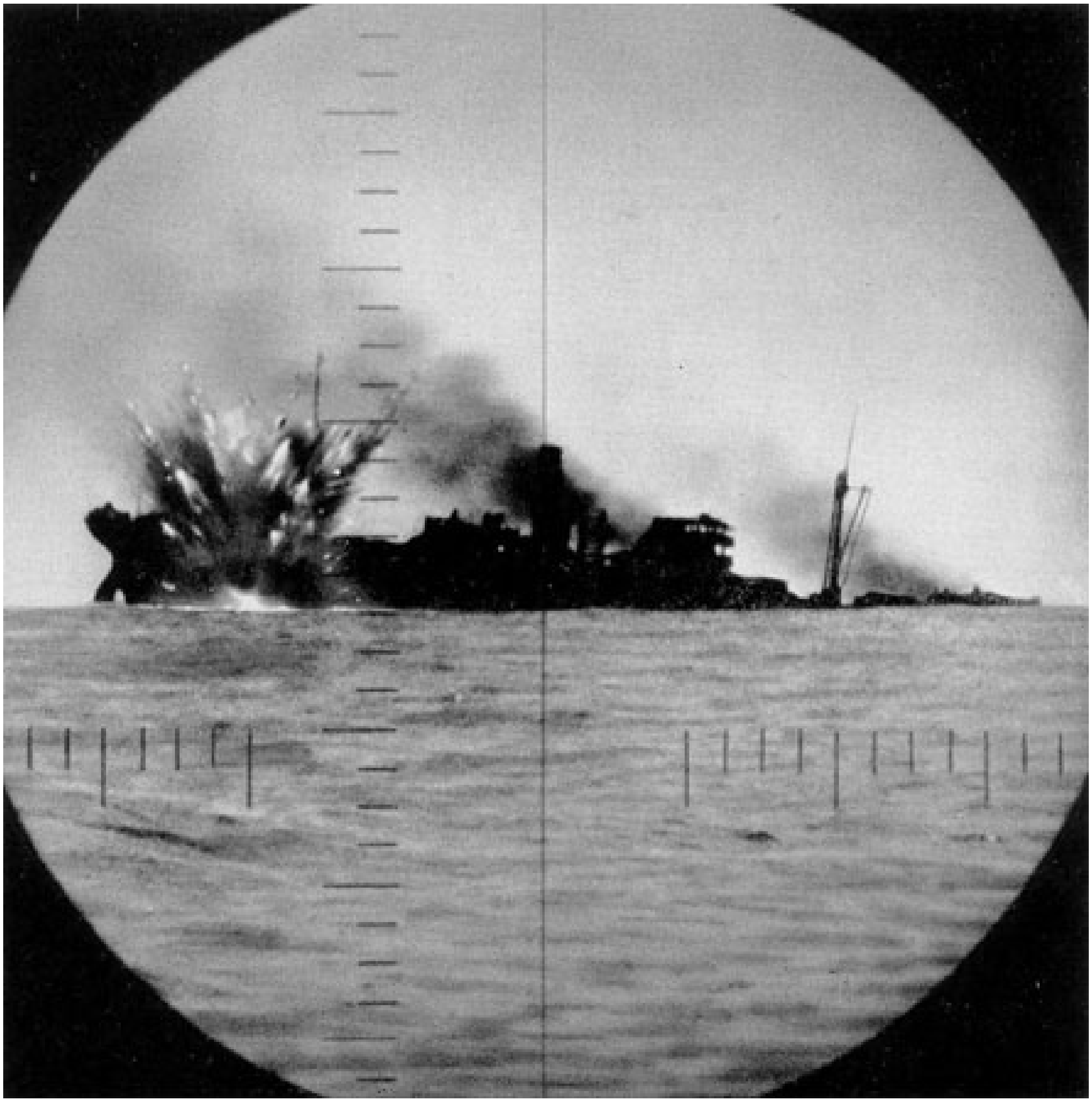
# PART I

## FLEET TYPE SUBMARINE
## MAIN AND AUXILIARY POWER



Electrical power helped do this.

Fleetsub Home Page  Next chapter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Search: Search

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Version 1.00, 9 Feb Jan 06

# SECTION 9-1
# GENERAL DESCRIPTION

## 1. INTRODUCTION.

The reliability of a ship' s electronic distribution system depends largely on its cable installation. Current carrying capacity of cables, their insulation strength, and their ability to withstand all kinds of service exposure, including heat, cold, dryness, bending, crushing, vibration, twisting, and shock are important - but the workmanship that goes into the cable installations is just as important.

The ratings and characteristics of the various classes of Navy shipboard cable are given in General Specification S62-2, NavShips 250-660-23 and supplementary matter. This section contains all the cable information needed by the electronics installation worker.

## 2. TYPES OF CABLES.

The principal classes of cable are briefly described here, with notes on the application of each.

a. HEAT AND FLAME RESISTANT CABLES.- Most of the permanent wiring on shipboard is done with heat-and flame-resistant cables having protective armor. These cables use synthetic resin or varnished cambric as primary insulation supplemented by asbestos for heat-and flame-resistance and covered by a braided, protective armor. They are designated by the letters "HFA" and include the following types:

SHFA - Single-conductor
DHFA- Twin-conductor
THFA- Three-conductor
FHFA - Four-conductor
MHFA- Multi-conductor
TTHFWA - Twisted-pair, telephone

Multi-conductor cables are available with up to 44 conductors, each conductor having a cross-sectional area of 2828 circular mils.

Twisted-pair telephone cables are available with up to 60 pairs of conductors, each conductor having a cross-sectional area of 703 circular mils.

SHFA, DHFA, THFA, and FHFA type cables are available in various sizes of circular mils and are used mostly with the power and lighting system.

b. REDUCED-DIAMETER CABLES. - The new, reduced-diameter, type "SGA" cables are smaller and lighter weight than the "HFA" types but have design features that give them greater insulation strength and equivalent heat-and flame-resistance as the larger cables and will let them be used for the same service as the "HFA" types. Widely used "SGA" cables are:

SSGA - Single-conductor
DSGA - Twin-conductor
TSGA - Three-conductor
FSGA- Four-conductor

Multi-conductor cable in this class (Type MSCA) is made up of stranded conductors, each having seven strands of 0.016 inch diameter copper for a total area of 1779 circular mils per conductor.

c. CABLES FOR REPEATED FLEXING SERVICE.-Many applications aboard ship require cables that can be bent and twisted again and again without damaging the conductor, insulation, or protective covering.

Such cables are generally used with portable equipment but are sometimes permanently installed to connect circuits in rotating structures to the distribution wiring of the ship.

Flexible cables have synthetic rubber or synthetic resin insulation and a sheath that is resistant to water, oil, heat, and flame. They are not as heat-and-flame-resistant as armored "HFA" and "SGA" cables. Flexible cables are of the following types:

SCOP- Single-conductor, oil-resistant, portable.

DCOP- Double-conductor, oil-resistant, portable.

TCOP- Triple-conductor, oil-resistant, portable.

FCOP- Four-conductor, oil-resistant, portable.

MCOP- Multiple-conductor, oil-resistant, portable.

MCOS- Multiple-conductor, oil-resistant, shielded (shielding over individual pair or shielding over assembly).

New flexible cables, types SHOF, DHOF, THOF and FHOF are identical in diameter and weight to corresponding sizes of the COP cables. The only difference between these two types is in the grade of insulating material on the individual conductors. The HOF cable uses a special heat-resistant synthetic (butyl) rubber insulation and may be operated continuously at temperatures above the limits permissible for type COP cables. The result is a higher current-carrying capacity and a reduction in cable weight, since it is possible to use a smaller size in type HOF cable than in type COP for a given application.

d. OTHER CABLE TYPES. - Other types of cables commonly used in electronic work are:

DRHLA- double - conductor, radio, high-tension, lead armored.

DRLL- Double - conductor, radio, lead-sheathed.

MCSP- Multiple-conductor, shielded, pressure-resisting (submarine applications).

PBLW- Pyrometer base lead wire.

TTRSA- Twisted-pair telephone, radio shielded, armored,(characteristic impedance approximately 76(ohms).

DSS- Double conductor, special purpose, shielded.

TSS- Three conductor, special purpose, shielded.

FSS- Four conductor, special purpose, shielded.

MSS- Multiple conductor, special purpose, shielded.

More information such as current rating, resistance per foot, and stuffing tube sizes is given for all of these types in the tabulated data section.

c. WATERTIGHT AND NON-WATER-TIGHT CABLE. - The heat-and-flame-resistant, armored cables under Specification MIL-C-915 (Ships) are made watertight by filling all voids within the stranded copper conductors and all spaces between insulated conductors within the cable core with compounds which block the entrance of water. The new reduced diameter cables are of watertight construction.

3. DESIGNATION OF CONDUCTOR SIZE.

Conductor sizes are designated by numbers that are to the nearest thousand of the actual circular mil area. These numbers follow the type and class designation.

EXAMPLE: TSGA-60 is a reduced-diameter, three-conductor, armored cable for general shipboard use, with each conductor having a cross-sectional area of 60,090 circular mils.

4. MULTIPLE -CONDUCTOR -CABLE DESIGNATIONS.

Multiple - conductor - cable types and class designations are followed by a number that indicates the number of conductors.

EXAMPLES: MSCA-30 is a heat- and flame-resistance, armored cable with 30 conductors.

For telephone cable, the number indicates twisted pairs.

| | |
|---|---|
| TTHFWA-25 | 25 twisted pairs |
| TTRSA-4 | 4 pairs, individually shielded. |

5. SELECTION OF CABLE SIZE.

Current-carrying capacity and voltage drop limitations, determine the size cable for a particular application. The current capacity is dependent upon the type and size of the conductor, the permissible temperature rise, and the character of the space in which the cable is installed,

6. BASIC CABLE INSTALLATION DATA.

a. CABLE CONNECTIONS. -All connections to cables and at normal breaks in a cable, should be enter non-watertight equipment, the following should be observed:

> Sheet steel enclosures, bulkhead mounted; use stuffing tubes
>
> Sheet steel enclosures, overhead mounted; use stuffing tubes or cable clamps
>
> Cast metal enclosures up to and including 3/16 inch thick; use cable clamps
>
> Cast metal enclosures over 3/16 inch thick; use stuffing tubes

c. PASSING THROUGH DECKS AND BULKHEADS.- Where cables pass through decks and water -tight bulkheads, watertight stuffing tubes should be used. Where cables pass through non-watertight bulkheads 1/4 inches thick, or more, no stuffing tubes are used; simply pass cable through drilled, smoothed holes. Where the bulkheads are less than 1/4 inches in thickness, bushings should be used. All cables passing through decks should be protected from mechanical injury by kickpipes or riser boxes. A kickpipe is a length of steel pipe welded to the deck and having a stuffing tube threaded to the upper end.

d. CABLE BENDS.- Bending cables too sharply will damage them. The correct minimum radius for each type of cable is given in table 9-1.

e. SUPPORTING CABLE ON DECKS AND BULKHEADS. -The methods for supporting cable depend upon the number and size of cables in a particular run, thickness of bulkhead or deck, obstructions to direct runs, heat and moisture conditions, structural material, water-tight conditions and other conditions taken up later in the chapter.

made in standard appliances and fittings. Don't make splice connections.

b. CABLE ENTRANCES. -Cables entering water-tight equipment should be brought into the equipment through Navy Standard Stuffing tubes. When cables



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SECTION 9-2

CHOOSING PROPER SIZE AND
CALCULATING VOLTAGE DROP

1. CABLE SERVICE RATINGS.

Cable installations are rated according to the ambient temperature the cable operates in. Ratings are: general, restricted and isolated corresponding to normal, poor and good heat conditions.

a. GENERAL CABLE RATINGS. -General ratings apply to cables installed under the conditions that are most common in Naval service. (Ambient Temperature 40° to 50°C) Typical examples are:

Cables installed in racks, with not more than three cables next to each other carrying current at the same time. Cables spaced one-half inch apart no matter how many of the cables are carrying current at once.

Cables installed in armored trunks, when the load is intermittent and the armor is more than two inches thick.

The current-carrying capacities given in the tables apply to **general** cable ratings.

b. RESTRICTED CABLE RATINGS. - Restricted ratings apply to cables installed where the ambient temperature is greater than normal (50°C or greater) A typical example is:

**made to install cables so that the restricted rating need not be applied.**

c. ISOLATED CABLE RATINGS.- Isolated ratings apply when there are no hot objects or loaded cables close by or when heat insulation reduces the amount of heat that can reach the cable. Typical examples are:

Single cables, in free air or clamped to steel or aluminum decks or bulkheads.

Cables, in groups of two, clamped to decks or bulkheads of steel, aluminum, or other material that carries heat away rapidly.

Cables in racks where none of the cables run hot.

Under such favorable conditions, cables can be loaded 10% above the current-carrying capacities given in the table for **general** ratings.

2. CHOOSING CABLE SIZE.

To choose the right size cable for a particular application, it is necessary to know the following:

Gables installed next to each other in racks, with three or more cables carrying current at the same time.

When cables are installed so that restricted ratings have to apply, their current carrying capacities are 15% less than the values given in the tables for general ratings. **Every effort should be**

a. The maximum connected load in amperes

b. The possible added load due to future connection of more equipment

c. The demand factor

d. The cable service rating

e. The maximum allowable voltage drop for the part of the circuit under consideration.



The first four govern the size of conductor necessary to carry the load without overheating; the last may call for an increase in the conductor size so as to reduce the circuit resistance enough to keep the voltage drop below the allowable value. The maximum connected load is found by adding up the full-load ampere ratings of all the equipment connected to the circuit.

The demand factor is 1.0 for a power cable supplying a single load; it is 0.9 for a power cable supplying a group of several loads. The current value to use in choosing the conductor size is reached by adding the maximum connected load to the allowance for future load and multiplying this total by the demand factor. This value of **resultant load amperes** is used to find, in Table 9-1, a cable of the desired size that is safely rated to handle the load. If the cable is to have a **restricted** service rating, the resultant load amperes figure should be increased 15% before the conductor size is chosen from Table 9-1. If the **isolated** service rating is to apply, the resultant load amperes figure may be decreased 10% before the conductor size is chosen.

The cable chosen on the basis described above will be large enough to carry the maximum load without overheating, but it is also necessary to be sure the voltage drop is below the allowable maximum. Percentage voltage drop is the difference in voltage between any two points on a circuit expressed as a percentage of the rated switchboard or transformer secondary no-load voltage.

For all electronic installations, the maximum allowable percentage voltage drop between switchboard or transformer panel for circuits above 100 volts is 2%. For circuits of less than 100 volts, such as control and interlock, the maximum allowable percentage voltage drop is 5%. Since the majority of circuits use voltages above 100, Table 9-2 shows how many feet of each standard cable size can be used at different loads without exceeding the 2% voltage drop. These results are approximate. A method of computing length of cable run for a desired percentage voltage drop is shown in Section 2, Paragraph 4.

TABLE 9-1

Table 9-1 is a cable comparison chart in which all the type cables the electronics installation worker may work with are divided into four major groups, as follows:

Heat and flame resistant, non-flexing service.

Special purpose cables.

Twisted pair telephone cable, armored.

Heat, flame, oil resistant, repeated flexing service.

Cable sizes up to 30,000 circular mils are included in most cases. Larger sizes are not listed since their use in electronic installations is limited. A table on steel stuffing tube information is included here giving tube clearance drill size and the inner diameter of the gland nut for all the sizes to make the table 9-1 as complete and useful as possible.

In conjunction with the use of these tables, the following should be noted:

It should be noted that where a maximum DC voltage of 1000 is specified, the maximum AC voltage is 600.

The reduced diameter cables (DSGA, TSGA, FSGA, and MSCA) are being procured for use on new construction and certain electronics installations where HFA types were formerly used.

Similarly, the HOF type cables (SHOF, DHOF, THOF and FHOF) replace the COP types (SCOP, DCOP, TCOP, and FCOP) and are now called for on new construction.

Cable types TTRS and TTRSA, twisted pair telephone cable, have properties which make them useful as R.F. cable. These properties are listed in the table.



| TYPE | NUMBER OF CONDUCTORS | CM AREA/ COND. | MAXIMUM AMPERES RATING AT 40 °C AMB. | MAXIMUM AMPERES RATING AT 50 °C AMB. | MAXIMUM VOLTAGE D. C. BETWEEN COND. | MAXIMUM CONDUCTOR RESISTANCE PER FOOT AT 25°C | ESTIMATED WEIGHT PER FOOT (LBS) | OVERALL DIAMETER- INCHES | MINIMUM RADIUS OF BEND- INCHES | SIZE OF STUFFING TUBE | TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SHFA-3 | 1 | 2828 | 15 | 14 | 1000 | .00392 | .068 | .355 | 2.5 | A | SHFA-3 |
| SHFA-4 | 1 | 4497 | 26 | 24 | 1000 | .00246 | .134 | .500 | 3.0 | C | SHFA-4 |
| SHFA-9 | 1 | 9016 | 53 | 49 | 1000 | .00123 | .230 | .556 | 4.0 | D | SHFA-9 |
| SHFA-14 | 1 | 14340 | 71 | 65 | 1000 | .000784 | .262 | .684 | 4.5 | D | SHFA-14 |
| SHFA-23 | 1 | 22800 | 92 | 85 | 1000 | .000493 | .306 | .719 | 4.5 | D | SHFA-23 |
| SHFA-30 | 1 | 30860 | 113 | 104 | 1000 | .000365 | .346 | .749 | 5.0 | E | SHFA-30 |
| DHFA-3 | 2 | 2828 | 13 | 12 | 1000 | .00400 | .143 | .530 | 3.5 | C | DHFA-3 |
| DHFA-4 | 2 | 4497 | 22 | 20 | 1000 | .00250 | .294 | .778 | 5.0 | E | DHFA-4 |
| DHFA-9 | 2 | 9016 | 44 | 41 | 1000 | .00126 | .361 | .842 | 5.5 | G | DHFA-9 |
| DHFA-14 | 2 | 14340 | 60 | 55 | 1000 | .000800 | .451 | .922 | 6.0 | G | DHFA-14 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DHFA-23 | 2 | 22800 | 78 | 72 | 1000 | .000505 | .555 | .992 | 6.5 | J | DHFA-23 |
| DHFA-30 | 2 | 30860 | 94 | 87 | 1000 | .000362 | .694 | 1.110 | 7.0 | K | DHFA-30 |
| THFA-3 | 3 | 2828 | 11 | 10 | 1000 | .00400 | .171 | .560 | 3.5 | C | THFA-3 |
| THFA-4 | 3 | 4497 | 18 | 17 | 1000 | .00250 | .334 | .812 | 5.0 | F | THFA-4 |
| THFA-9 | 3 | 9016 | 39 | 36 | 1000 | .00126 | .413 | .881 | 5.5 | G | THFA-9 |
| THFA-14 | 3 | 14340 | 51 | 47 | 1000 | .000800 | .527 | .968 | 6.0 | J | THFA-14 |
| THFA-23 | 3 | 22800 | 69 | 64 | 1000 | .000505 | .659 | 1.040 | 6.5 | J | THFA-23 |
| THFA-30 | 3 | 30860 | 84 | 77 | 1000 | .000362 | .855 | 1.170 | 7.5 | L | THFA-30 |
| FHFA-3 | 4 | 2828 | 11 | 10 | 1000 | .00400 | .205 | .610 | 4.0 | C | FHFA-3 |
| FHFA-4 | 4 | 4497 | 18 | 17 | 1000 | .00250 | .389 | .865 | 5.5 | G | FHFA-4 |
| MHFA-7 | 7 | 2628 | 8 | 6 | 1000 | .00403 | .383 | .859 | 5.5 | G | MHFA-7 |
| MHFA-10 | 10 | 2828 | 8 | 6 | 1000 | .00403 | .516 | 1.04 | 6.5 | J | MHFA-10 |
| MHFA-14 | 14 | 2828 | 8 | 6 | 1000 | .00403 | .634 | 1.12 | 7.5 | K | MHFA-14 |
| MHFA-19 | 19 | 2828 | 8 | 6 | 1000 | .00403 | .764 | 1.21 | 8.0 | L | MHFA-19 |
| MHFA-24 | 24 | 2828 | 6 | 5 | 1000 | .00403 | ,951 | 1.375 | 9.0 | M | MHFA-24 |
| MHFA-30 | 30 | 2828 | 6 | 5 | 1000 | .00403 | 1.09 | 1.46 | 9.5 | N | MHFA-30 |
| MHFA-37 | 37 | 2828 | 6 | 5 | 1000 | .00403 | 1.29 | 1.57 | 10.5 | P | MHFA-37 |
| MHFA-44 | 44 | 2828 | 5 | 4 | 1000 | .00403 | 1.5 | 1.734 | 11.0 | R | MHFA-44 |

TABLE 9-1a. HEAT AND FLAME RESISTANT, NON-FLEXING SERVICE

| TYPE | NUMBER OF CONDUCTORS | CM AREA/ COND. | MAXIMUM AMPERES RATING AT 40 °C AMB. | MAXIMUM AMPERES RATING AT 50 °C AMB. | MAXIMUM VOLTAGE D. C. BETWEEN COND. | MAXIMUM CONDUCTOR RESISTANCE PER FOOT AT 25°C | ESTIMATED WEIGHT PER FOOT (LBS) | OVERALL DIAMETER-INCHES | MINIMUM RADIUS OF BEND-INCHES | SIZE OF STUFFING TUBE | TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SSGA-3 | 1 | 2828 | 15 | 14 | 1000 | .00392 | .044 | .305 | 2.0 | A | SSGA-3 |
| SSGA-4 | 1 | 4497 | 26 | 24 | 1000 | .00246 | .053 | .323 | 2.0 | A | SSGA-4 |
| SSGA-9 | 1 | 9016 | 53 | 49 | 1000 | .00123 | .079 | .371 | 2.5 | A | SSGA-9 |
| SSGA-14 | 1 | 14340 | 71 | 65 | 1000 | .000770 | .102 | .414 | 2.5 | B | SSGA-14 |
| SSGA-23 | 1 | 22800 | 92 | 85 | 1000 | .000486 | .140 | .453 | 3.0 | B | SSGA-23 |
| SSGA-30 | 1 | 30860 | 113 | 104 | 1000 | .000358 | .165 | .484 | 3.0 | B | SSGA-30 |
| DSGA-3 | 2 | 2828 | 13 | 12 | 1000 | .00400 | .087 | .441 | 3.0 | B | DSGA-3 |
| DSGA-4 | 2 | 4497 | 22 | 20 | 1000 | .00251 | .108 | .477 | 3.0 | B | DSGA-4 |
| DSGA-9 | 2 | 9016 | 44 | 41 | 1000 | .00126 | .183 | .594 | 4.0 | C | DSGA-9 |
| DSGA-14 | 2 | 14340 | 60 | 55 | 1000 | .000785 | .258 | .680 | 4.0 | D | DSGA-14 |
| DSGA-23 | 2 | 22800 | 78 | 72 | 1000 | .000496 | .345 | .781 | 5.0 | E | DSGA-23 |
| DSGA-30 | 2 | 30860 | 94 | 87 | 1000 | .000365 | .430 | .852 | 5.5 | G | DSGA-30 |
| TSGA-3 | 3 | 2828 | 11 | 10 | 1000 | .00400 | .104 | .461 | 3.0 | B | TSGA-3 |
| TSGA-4 | 3 | 4497 | 18 | 17 | 1000 | .00251 | .130 | .499 | 3.0 | B | TSGA-4 |
| TSGA-9 | 3 | 9016 | 39 | 36 | 1000 | .00126 | .224 | .625 | 4.0 | C | TSGA-9 |
| TSGA-14 | 3 | 14340 | 51 | 47 | 1000 | .000785 | .325 | .718 | 4.5 | D | TSGA-14 |
| TSGA-23 | 3 | 22800 | 69 | 64 | 1000 | .000496 | .430 | .812 | 5.0 | F | TSGA-23 |
| TSGA-30 | 3 | 30860 | 84 | 77 | 1000 | .000365 | .560 | .902 | 5.5 | G | TSGA-30 |
| FSGA-3 | 4 | 2828 | 11 | 10 | 1000 | .00400 | .124 | .497 | 3.5 | B | FSGA-3 |
| FSGA-4 | 4 | 4497 | 18 | 17 | 1000 | .00251 | .172 | .563 | 4.0 | C | FSGA-4 |
| FSGA-9 | 4 | 9016 | 39 | 36 | 1000 | .00126 | .276 | .680 | 4.5 | D | FSGA-9 |
| MSCA-7 | 7 | 1779 | 8 | 6 | 1000 | .00637 | .152 | .534 | 4.0 | C | MSCA-7 |
| MSCA-10 | 10 | 1779 | 8 | 6 | 1000 | .00637 | .234 | .672 | 5.0 | D | MSCA-10 |
| MSCA-14 | 14 | 1779 | 8 | 6 | 1000 | .00637 | .282 | .718 | 5.5 | D | MSCA-14 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MSCA-19 | 19 | 1779 | 8 | 6 | 1000 | .00637 | .347 | .788 | 6.0 | E | MSCA-19 |
| MSCA-24 | 24 | 1779 | 6 | 5 | 1000 | .00637 | .447 | .905 | 6.5 | G | MSCA-24 |
| MSCA-30 | 30 | 1779 | 6 | 5 | 1000 | .00637 | .511 | .951 | 7.0 | J | MSCA-30 |
| MSCA-37 | 37 | 1779 | 6 | 5 | 1000 | .00637 | .601 | 1.022 | 7.5 | J | MSCA-37 |
| MSCA-44 | 44 | 1779 | 5 | 4 | 1000 | .00637 | .732 | 1.134 | 8.5 | K | MSCA-44 |

NOTE: SSGA replaces Type SHFA, SDGA replaces Type DHFA, TSGA replaces Type THFA, FSGA replaces Type FHFA, MSCA replaces Type MHFA.

TABLE 9-1b. HEAT AND FLAME RESISTANT, NON-FLEXING SERVICE



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| TYPE | NUMBER OF PAIRS | CM AREA/ COND. | INDIVIDUAL MAX. AMPS. | AVERAGE AMPS. AT 40°C AMB. | INDIVIDUAL MAX. AMPS. | AVERAGE AMPS. AT 50°C AMB. | MAXIMUM VOLTAGE D.C. * BETWEEN COND. | MAXIMUM CONDUCTOR RESISTANCE PER FOOT AT 25°C | ESTIMATED WEIGHT PER FOOT (LBS) | OVERALL DIAMETER-INCHES | MINIMUM RADIUS OF BEND-INCHES | SIZE OF STUFFING TUBE | TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TTHFWA-1 ½ | 1 ½ | 704 | 4 | 4 | 3 | 3 | 500 | .0162 | .097 | .380 | 2.5 | B | TTHFWA-1 ½ |
| TTHFWA-3 | 3 | 704 | 4 | 3 | 3 | 2 | 500 | .0162 | .139 | .500 | 3.5 | C | TTHFWA-3 |
| TTHFWA-5 | 5 | 704 | 4 | 2 | 3 | 1 | 500 | .0162 | .180 | .590 | 4.0 | C | TTHFWA-5 |
| TTHFWA-10 | 10 | 704 | 4 | 1 | 3 | .50 | 500 | .0162 | .243 | .690 | 4.5 | D | TTHFWA-10 |
| TTHFWA-15 | 15 | 704 | 4 | .75 | 3 | .375 | 500 | .0162 | .290 | .800 | 5.5 | F | TTHFWA-15 |
| TTHFWA-20 | 20 | 704 | 4 | .50 | 3 | .25 | 500 | .0162 | .331 | .889 | 6.0 | G | TTHFWA -20 |
| TTHFWA-30 | 30 | 704 | - | - | - | - | 500 | .0162 | .422 | 1.030 | 7.0 | J | TTHFWA-30 |
| TTHFWA-40 | 40 | 704 | - | - | - | - | 500 | .0162 | .507 | 1.130 | 7.5 | K | TTHFWA-40 |
| TTHFWA-50 | 50 | 704 | - | - | - | - | 500 | .0162 | .594 | 1.265 | 8.5 | M | TTHFWA-50 |
| TTHFWA-60 | 60 | 704 | - | - | - | - | 500 | .0 162 | .736 | 1.350 | 9.0 | N | TTHFWA-60 |

* NOTE. Maximum voltage AC between conductors is 300.

TABLE 9-1c. HEAT AND FLAME RESISTANT, NON-FLEXING SERVICE



| TYPE | NUMBER OF CONDUCTORS | CM AREA/ COND. | MAXIMUM APERES RATING AT 40°C AMB. | MAXIMUM AMPERES RATING AT 50°C AMB. | MAXIMUM VOLTAGE AC BETWEEN COND. | MAXIMUM CONDUCTOR RESISTANCE PER FOOT AT 25°C | ESTIMATED WEIGHT PER FOOT (LBS) | MINIMUM RADIUS OF BEND- INCHES | OVERALL DIAMETER- INCHES | SIZE OF STUFFING TUBE | TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DRLL-4 | 2 | 4497 | 17 | 13 | 300 | | | .295 X .520 | 1.0 | | DRLL-4 |
| MCSP-6 | 2 Shielded Pair 2 Singles | 1005 | Microphone Cable | | 300 | .0114 | .150 | .595 | 1.0 | C | MCSP-6 |
| PBLW-4 | 2 One wire is iron the other is Constantin | | Pyrometer Base Lead Wire | | | | .135 | .480 | | | PBLW-4 |
| DSS-2 | 2 | | | | | .00664 | | .390 | | | DSS-2 |
| DSS-3 | 2 | | | | | .00415 | | .445 | | | DSS-3 |
| TSS-4 | 3 | | | | | .00257 | | .500 | | | TSS-4 |
| FSS-2 | 4 | | | | | .00664 | | .465 | | | FSS-2 |
| MSS-6 | 6 | | | | | .0105 | | .490 | | | MSS-6 |
| | | | | | RADIO HIGH VOLTAGE | | | | | | |
| SHFR-4 | 1 | 4497 | 32 | 30 | 3000 | | .135 | .540 | 3.5 | C | SHFR-4 |
| DHFR-4 | 2 | 4497 | 26 | 24 | 3009 | | .325 | .844 | 5.0 | G | DHFR-4 |
| THFR-4 | 3 | 4497 | 24 | 22 | 3000 | | .369 | .883 | 5.5 | G | THFR-4 |
| SRHLA-4 | 1 | 4494 | - | - | 15000 | | - | 1.10 | - | - | SRHLA-4 |
| DRHLA-4 | 2 | 4494 | - | - | 15000 | | - | 1.995 | - | - | DRHLA-4 |

TABLE 9-1d. SPECIAL PURPOSE CABLES

| TYPE | NUMBER OF SHIELDED PAIRS | CM AREA/ COND. | CHARACTERISTICS | ESTIMATED WEIGHT PER FOOT (LBS) | OVERALL DIAMETER- INCHES | MINIMUM RADIUS OF BEND- INCHES | SIZE OF STUFFING TUBE | TYPE |
|---|---|---|---|---|---|---|---|---|
| TTRSA-2 | 2 | 1119 | (Sometimes used as Radio | .290 | .740 | 5.0 | E | TTRSA-2 |
| TTRSA-4 | 4 | 1119 | Frequency cable) | .385 | .800 | 5.5 | F | TTRSA-4 |
| TTRSA-6 | 6 | 1119 | | .460 | .940 | 6.0 | J | TTRSA-6 |
| TTRSA-8 | 8 | 1119 | Maximum voltage AC between | .510 | 1.050 | 6.5 | K | TTRSA-8 |
| TTRSA-10 | 10 | 1119 | conductors - 300 (500v DC) | .590 | 1.140 | 7.0 | K | TTRSA-10 |
| TTRSA-12 | 12 | 1119 | | .650 | 1.160 | 7.5 | L | TTRSA-12 |
| TTRSA-16 | 16 | 1119 | Surge Impedance of a pair = 76 ohms | .750 | 1.250 | 8.0 | M | TTRSA-16 |
| TTRS-2 | 2 | 1119 | | - | .680 | | D | TTRS-2 |
| TTRS-4 | 4 | 1119 | Maximum Capac. of a pair = | .160 | .740 | | E | TTRS-4 |
| TTRS-6 | 6 | 1119 | 25 MMF/ft. at 25°C | .315 | .880 | | G | TTRS-6 |
| TTRS-8 | 8 | 1119 | | .450 | .990 | | J | TTRS-8 |
| TTRS-10 | 10 | 1119 | Maximum Resistance per Conductor | .500 | 1.080 | | K | TTRS-10 |
| TTRS-12 | 12 | 1119 | (coated) per foot = .0109 | .560 | 1.100 | | K | TTRS-12 |
| TTRS-16 | 16 | 1119 | ohms at 25°C | .675 | 1.190 | | L | TTRS-16 |

TABLE 9-1e. TWISTED PAIR, TELEPHONE, RADIO, SHIELDED CABLE - ARMORED AND UNARMORED.



| TYPE | NUMBER OF CONDUCTORS | CM AREA/ COND. | MAXIMUM AMPERES RATING AT 40°C AMB. | MAXIMUM AMPERES RATING AT 50°C AMB. | MAXIMUM VOLTAGE D. C. BETWEEN COND. | MAXIMUM CONDUCTOR RESISTANCE PER FOOT AT 25° C | ESTIMATED WEIGHT PER FOOT (LBS) | OVERALL DIAMETER- INCHES | SIZE OF STUFFING TUBE | TYPE |
|---|---|---|---|---|---|---|---|---|---|---|
| DCOP-2 | 2 | 1608 | 6 | 4 | 300 | .00722 | .065 | .330 | A | DCOP-2 |
| *DCOP-3 | 2 | 2613 | 12 | 8 | 1000 | .00443 | .099 | .425 | B | *DCOP-3 |
| *DCOP-4 | 2 | 4121 | 16 | 11 | 1000 | .00281 | .115 | .460 | B | *DCOP-4 |
| *DCOP-6 | 2 | 6533 | 22 | 16 | 1000 | .00176 | .146 | .510 | C | *DCOP-6 |
| *DCOP-9 | 2 | 9045 | 29 | 20 | 1000 | .00127 | .167 | .570 | C | *DCOP-9 |
| *DCOP-14 | 2 | 14070 | 40 | 29 | 1000 | .000810 | .285 | .705 | D | *DCOP-14 |
| *DC0P-23 | 2 | 22910 | 58 | 41 | 1000 | .000513 | .402 | .860 | G | *DCOP-23 |
| *DCOP-30 | 2 | 30550 | 72 | 49 | 1000 | .000382 | .606 | .960 | J | *DCOP-30 |
| TCOP-2 | 3 | 1608 | 7 | 5 | 300 | .00722 | .049 | .345 | A | TCOP-2 |
| *TCOP-3 | 3 | 2613 | 10 | 6 | 1000 | .00443 | .092 | .450 | B | *TCOP-3 |
| *TCOP-4 | 3 | 4121 | 14 | 9 | 1000 | .00281 | .133 | .480 | B | *TCOP-4 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *TCOP-6 | 3 | 6533 | 19 | 12 | 1000 | .00176 | .174 | .550 | C | *TCOP-6 |
| *TCOP-9 | 3 | 9045 | 25 | 16 | 1000 | .00127 | .196 | .600 | C | *TCOP-9 |
| *TCOP-14 | 3 | 14070 | 33 | 21 | 1000 | .000810 | .305 | .750 | E | *TCOP-14 |
| *TCOP-23 | 3 | 22910 | 48 | 31 | 1000 | .000513 | .518 | .900 | G | *TCOP-23 |
| *TCOP-30 | 3 | 30550 | 75 | 43 | 1000 | .000278 | .958 | 1.250 | L | *TCOP-30 |
| *FCOP-3 | 4 | 2613 | 8 | 5 | 1000 | .00443 | .127 | .480 | B | *FCOP-3 |
| *FCOP-4 | 4 | 4121 | 13 | 11 | 1000 | .00281 | .162 | .550 | C | *FCOP-4 |
| *FCOP-9 | 4 | 9045 | 21 | 18 | 1000 | .00127 | .273 | .660 | D | *FCOP-9 |

*Cables suitable for use through the pressure-proof hull
NOTE: HOF Types replace COP Types

TABLE 9-1f. HEAT, FLAME, OIL RESISTANT, REPEATED FLEXING SERVICE



| TYPE | SIZE OF STUFFING TUBE | OVERALL DIAMETER-INCHES | ESTIMATED WEIGHT PER FOOT (LBS) | MAXIMUM CONDUCTOR RESISTANCE PER FOOT AT 25° C | MAXIMUM VOLTAGE D. C. BETWEEN COND. | MAXIMUM AMPERES RATING AT 50°C AMB. | MAXIMUM AMPERES AT 40°C AMB. | CM AREA/ COND. | NUMBER OF CONDUCTORS | TYPE |
|---|---|---|---|---|---|---|---|---|---|---|
| *DHOF-3 | 2 | 2613 | 23 | 21 | 1000 | .00437 | .099 | .425 | B | *DHOF-3 |
| *DHOF-4 | 2 | 4121 | 30 | 28 | 1000 | .00281 | .115 | .460 | B | *DHOF-4 |
| *DHOF-6 | 2 | 6533 | 41 | 37 | 1000 | .00176 | .146 | .510 | C | *DHOF-6 |
| *DHOF-9 | 2 | 9045 | 50 | 45 | 1000 | .00127 | .167 | .570 | C | *DHOF-9 |
| *DHOF-14 | 2 | 14070 | 60 | 54 | 1000 | .00081 | .285 | .705 | D | *DHOE-14 |
| *DHOF-23 | 2 | 22910 | 80 | 72 | 1000 | .000513 | .402 | .860 | G, | *DHOF-23 |
| *DHOF-30 | 2 | 30550 | 90 | 83 | 1000 | .000278 | .606 | .960 | J | *DHOF-30 |
| *THOF-3 | 3 | 2613 | 19 | 17 | 1000 | .00437 | .115 | .450 | B | *THOF-3 |
| *THOF-4 | 3 | 4121 | 25 | 23 | 1000 | .00281 | .133 | .480 | B | *THOF-4 |
| *THOF-6 | 3 | 6533 | 33 | 31 | 1000 | .00176 | .174 | .550 | C | *THOF-6 |
| *THOF-9 | 3 | 9045 | 38 | 34 | 1000 | .00127 | .196 | .600 | C | *THOF-9 |
| *THOF-14 | 3 | 14070 | 50 | 46 | 1000 | .00081 | .336 | .750 | E | *THOF-14 |
| *THOF-23 | 3 | 22910 | 70 | 64 | 1000 | .000513 | .518 | .900 | G | *THOF-23 |
| *FHOF-3 | 4 | 2613 | 17 | 16 | 1000 | .00437 | .127 | .480 | B | *FHOE-3 |
| *FHOF-4 | 4 | 4121 | 23 | 21 | 1000 | .00281 | .162 | .550 | C | *FHOE-4 |
| *FHOE-9 | 4 | 9045 | 36 | 34 | 1000 | .00127 | .273 | .660 | D | *FHOF-9 |

*Cables suitable for use through the pressure-proof hull
NOTE: HOF Types replace COP Types

**9-13**

| TYPE | NUMBER OF CONDUCTORS | CM AREA/ COND. | INDIVIDUAL MAX. AMPS. | AVERAGE AMPS. AT 40°C AMB. | INDIVIDUAL MAX. AMPS | AVERAGE AMPS. RATING AT 50°C AMB. | MAXIMUM VOLTAGE D.C. BETWEEN COND. | MAXIMUM CONDUCTOR RESISTANCE PER FOOT AT 25°C | ESTIMATED WEIGHT PER FOOT (LBS) | OVERALL DIAMETER- INCHES | SIZE OF STUFFING TUBE | TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MCOP-7 | 7 | 2613 | 8 | 5 | 6 | 4 | 1000 | .00437 | .200 | .627 | D | MCOP-7 |
| MCOP-10 | 10 | 2613 | 8 | 5 | 6 | 4 | 1000 | .00437 | .286 | .795 | E | MCOP-10 |
| MCOP-14 | 14 | 2613 | 8 | 5 | 6 | 4 | 1000 | .00437 | .377 | .844 | G | MCOP-14 |
| MCOP-19 | 19 | 2613 | 8 | 5 | 6 | 4 | 1000 | .00437 | .480 | .995 | J | NICOP-19 |
| MCOP-22 | 22 | 2613 | 8 | 4 | 6 | 3 | 1000 | .00437 | .649 | 1.070 | K | MCOP-22 |
| MCOP-26 | 26 | 2613 | 8 | 4 | 6 | 3 | 1000 | .00437 | .700 | 1.160 | L | MCOP-26 |
| MCOP-30 | 30 | 2613 | 8 | 4 | 6 | 3 | 1000 | .00437 | .762 | 1.190 | L | MCOP-30 |
| MCOP-37 | 37 | 2613 | 8 | 4 | 6 | 3 | 1000 | .00437 | .889 | 1,290 | M | MCOP-37 |
| MCOP-44 | 44 | 2613 | 8 | 3 | 6 | 2 | 1000 | .00437 | 1.111 | 1.420 | N | MCOP-44 |
| MCOS-2 | 2 | 1608 | 5 | 5 | 4 | 4 | 1000 | .00708 | .126 | .460 | B | 4COS-2 |
| MOOS-4 | 4 | 1608 | 5 | 3 | 4 | 2 | 1000 | .00708 | .162 | .510 | C | MCOS-4 |
| MCOS-6 | 6 | 1005 | 2.5 | 1 | 2 | 1 | 500 | .0114 | .102 | .465 | B | MCOS-6 |
| MCOS-7 | 7 | 1608 | 5 | 2.5 | 4 | 1.5 | 1000 | .00708 | .230 | .595 | C | MCOS-7 |
| MHFF-2 | 2 (PR) | 2613 | 11 | 9 | 9 | 8 | 1000 | .00437 | .107 | .460 | B | MHFF-2 |
| MHFF-4 | 4 | 2613 | 11 | 8 | 9 | 7 | 1000 | .00437 | .152 | .520 | C | MHFF-4 |
| *MHFF-7 | 7 | 2613 | 11 | 7 | 9 | 6 | 1000 | .00437 | .197 | .627 | D | *MHFF-7 |
| *MHFF-10 | 10 | 2613 | 11 | 7 | 9 | 6 | 1000 | .00437 | .300 | .795 | F | *MHFF-10 |
| *MHFF-14 | 14 | 2613 | 11 | 7 | 9 | 6 | 1000 | .00437 | .386 | .844 | G | *MHFF-14 |
| *MHFF-19 | 19 | 2613 | 11 | 7 | 9 | 6 | 1000 | .00437 | .502 | .995 | J | *MHFF-19 |
| *MHFF-24 | 24 | 2613 | 11 | 7 | 9 | 6 | 1000 | .00437 | .672 | 1.120 | K | *MHFF-24 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *MHFF-30 | 30 | 2613 | 11 | 7 | 9 | 6 | 1000 | .00437 | .793 | 1.194 | L | *MHFF-30 |
| *MHFF-37 | 37 | 2613 | 11 | 5 | 9 | 4 | 1000 | .00437 | .914 | 1.290 | M | *MHFF-37 |
| *MHFF-44 | 44 | 2613 | 11 | 4 | 9 | 3 | 1000 | .00437 | 1.130 | 1.420 | N | *MHFF-44 |

* Cables suitable for use through a pressure-proof hull



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| STEEL STUFFING TUBE INFORMATION | | |
|---|---|---|
| TUBE SIZE | TUBE CLEARANCE DRILL SIZE (INCHES) | I.D. GLAND NUT INCHES |
| A | .562 | .406 |
| B | .687 | .515 |
| C | .812 | .640 |
| D | .937 | .750 |
| E | 1.00 | .812 |
| F | 1.00 | .843 |
| G | 1.125 | .953 |
| J | 1.250 | 1.062 |
| K | 1.375 | 1.171 |
| L | 1.437 | 1.265 |
| M | 1.562 | 1.406 |
| N | 1.750 | 1.515 |
| P | 1.875 | 1.625 |
| R | 2.0 | 1.750 |
| S | 2.125 | 1.875 |
| T | 2.375 | 2.062 |
| V | 2.500 | 2.187 |
| W | 2.687 | 2.312 |
| X | 2.812 | 2.5 |
| Y | 2.937 | 2.609 |
| Z | 3.125 | 2.781 |
| AA | 3.187 | 2.875 |
| BB | 3.437 | 3.125 |

TABLE 9-li

**9-15**

| | D. C. or Single Phase - 2% Voltage Drop - 117 V. | | | | | | | | Three Phase - 2% Voltage Drop - 117 V. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Navy Standard Cond. Size | Base Column 1 Amp | 3 Amp. | 6 Amp. | 12 Amp. | 20 Amp. | 30 Amp. | 40 Amp. | 50 Amp. | Base Column 1 Amp. | 3 Amp. | 6 Amp. | 12 Amp. | 20 Amp. | 30 Amp. | 40 Amp. | 50 Amp. |
| -3 | 276 | 92 | 46 | 23 | - | - | - | - | 318 | 106 | 53 | 26 | - | - | - | - |
| -4 | 438 | 146 | 73 | 36 | 21 | - | - | - | 506 | 168 | 84 | 41 | 24 | - | - | - |
| -9 | 878 | 292 | 146 | 73 | 43 | 29 | 22 | - | 1012 | 337 | 168 | 84 | 49 | 33 | 25 | - |
| -14 | 1397 | 466 | 233 | 116 | 70 | 46 | 35 | 28 | 1612 | 537 | 269 | 134 | 80 | 53 | 40 | 32 |
| -23 | 2220 | 740 | 370 | 185 | 111 | 74 | 55 | 44 | 2560 | 853 | 427 | 213 | 128 | 85 | 63 | 50 |
| -30 | 3004 | 1003 | 501 | 250 | 150 | 100 | 75 | 60 | 3470 | 1160 | 577 | 292 | 173 | 115 | 86 | 69 |
| -40 | 3794 | 1265 | 633 | 316 | 190 | 126 | 95 | 76 | 4375 | 1460 | 731 | 364 | 219 | 145 | 109 | 87.7 |
| -50 | 4785 | 1595 | 797 | 390 | 239 | 159 | 119 | 95 | 5520 | 1840 | 918 | 449 | 275 | 183 | 137 | 109 |

Notes:

1. Fractional calculations for above were rounded off to the next lowest whole numbers.

2. Where Line Voltage is 220 V., multiply maximum allowable length by 1.88.

3. Where Line Voltage is 440 V. , multiply maximum allowable length by 3.76.

4. For applications where MHFA and MSCA are used, limit the current rating of each conductor to 1/2 Amp. With a load of 1/2 Amp. through a single phase circuit, the following maximum length of cable may be run to keep under the 2% voltage drop requirement:
MHFA (2828 C. M.) - 552 feet.
MSCA (1779 C. M.) - 347 feet.

TABLE 9-2
MAXIMUM ALLOWABLE LENGTH OF CABLE RUN FOR A GIVEN LOAD WITH A 2% VOLTAGE DROP

**9-16**

3. USE OF TABLE 9-2.

Table 9-2 shows the maximum lengths of cable run permissible at a given load current. The table may be applied to all cable types but the results are approximate.

To demonstrate the use of Table 9-2, two typical problems and their solutions are worked out.

**Problem 1**: Find the most suitable cable size for a 12-amp. , 117V. , single-phase load, to be run 69 feet. Percentage voltage drop to be less than 2%.

Solution: Refer to Table 9-1 and find the smallest cable size which allows a maximum load current of 12 amps. This would be size 3. Therefore our selection must be size 3 or larger.

Refer to Table 9-2 now, and under the vertical column 12 amps. , read down until a figure slightly greater than 69 is reached (in this case 73) and read horizontally to the left to get correct cable size, in this case 9.

**Problem 2**: Find the proper cable size for a 10 ampere, 117 volt, single phase load to run 25 feet. Percentage voltage drop to be less than 2%.

**Solution**: Since there is no column computed for 10 amperes, it is necessary to make use of the base column, computed on 1 ampere. The run in feet is a linear function of current, so the base column may simply be divided by the load current to obtain the maximum allowable run for that load.

For DSGA-3, a 1 -ampere load permits a run of 276 feet. Therefore, a 10-

4. MATHEMATICAL MEANS OF DETERMINING CABLE LENGTH.

An example calculation is given below showing the method for determining the length of cable that can be used for a maximum of 2% voltage drop using a given conductor size at a temperature of 45°C.

It is known that:

1. the source voltage is 117V.
2. single - phase operation
3. a load of 1 ampere is to be drawn
4. cable desired is HFA 3 (2828 CM)

The formula for finding the percent voltage drop is:

Percent voltage drop =
(R x 2*l*- x I x 100) / C.M. x E
(for single phase operation).

*l*= Length of cable

R = Resistivity of copper in circular mil feet at a given temperature (see Figure 9-1)

C.M.= Circular mil area of one conductor

E = Terminal voltage

(1) Therefore:

*l*=((% V.D.)(C.M.)(E)) / ((R)(2)(I) x 100)

The C. M. area may be found from Table 9-1 as corresponding to the standard conductor size (opposite any DHFA 3, THFA 3, etc.) as being, in this case 2828 C. M.

The resistivity (R) is in ohms per C. M. ft. at 45°C and is found from Figure 9-1,

ampere load allows a run of 276 y 10 or 27.6 feet which is within the limits required. DSGA-3 has a maximum rating of 12 amperes at 50°C, so that the cable is not overloaded with this choice.



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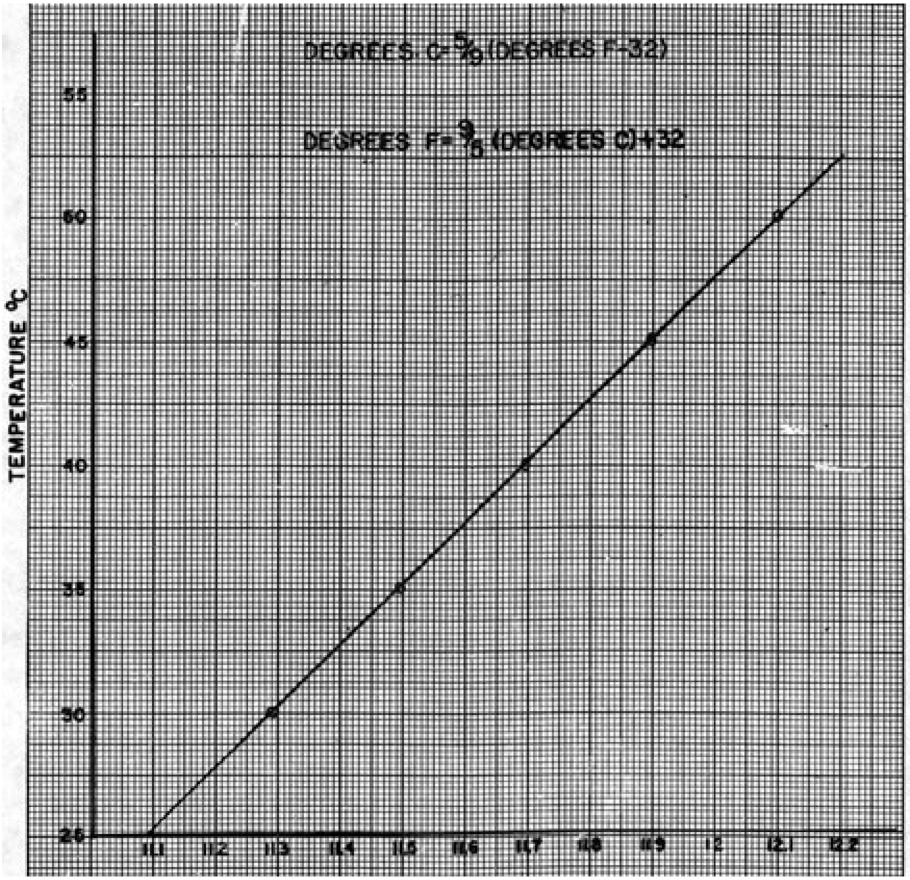
DEGREES C=5/9 (DEGREES F-32)
DEGREES F=9/5 (DEGREES C)+32




RESISTANCE (R) OHMS PER CIRCULAR MILFOOT

FIGURE 9-1
RESISIVITY VS. TEMPERATURE

Resistivity at 45 °C is approximately 12 ohms per circular mil foot. With the resistivity calculated it is a simple matter to substitute in formula (1) to determine length of conductor.

(1) $l$ =
((2 x 2828 x 117) / (12 x 2 x l x 100))
= 275.72 feet

The same procedure may be followed for voltages of 220 and 440 or if the length of feet is calculated for 117 volts; and entered in a chart, multiply the length by 1.88 or 220 volts and 3.76 for 440 volts at whatever load is to be used.

For 3-phase operation the formula used is:

(2) $l$ =

((% V.D.) (C.M.) (E)) /
((R) squareroot(3) (1) x 100))

As can be seen, the differences between formulas (1) and (2) is the squareroot(3) substituted for 2*l*. For this reason, to obtain 3 phase length, if those for single phase operation have already been calculated, multiply by 1.15. These lengths of course, represent the lengths for corresponding conductor size and load.



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# SECTION 9-3

# INSTALLING CABLE STRAPS AND HANGERS

## 1. UTILIZATION OF SPARES.

When the electronic installation worker needs to run a cable for a new installation, he should find out if there are spare cables in existing wireways, and spare stuffing tubes in bulkheads. If no spares are available in wireways, it will be necessary to make up additional straps and hangers.

## 2. METHOD OF MAKING STRAPS.

The material used in making straps is strap steel, 3/4 inches x 3/32 inches for overhead spans up to 6 inches wide. For all vertical runs, horizontal runs and overhead spans over 6 inches wide, use 3/4 inches x 1/8 inches steel.

Straps must fit the cables snugly to avoid chafing and vibration that would eventually damage the cables, so the straps must be accurately formed. This cannot be done easily on the job; it requires the use of shop equipment designed for convenience in forming straps to any desired shape. This equipment consists of a set of short, steel rods, in sizes corresponding to the diameters of all commonly used cables, and a clamping mechanism for holding any desired grouping of these rods.

The strap is clamped, at one end, to the rods and is formed to the shape of the rods by use of a hammer and drive bar. (See Figure 9-11).

Holes are then punched or drilled to clear a 5/16 inch -18 machine screw at appropriate locations. It is important to file all sharp edges from the straps and to remove any burrs from the drilled or punched holes.

Prior to mounting the cable straps, a protective coating, such as zinc plating, to give a good metal to metal contact between armor and cable strap, should be given the straps in order to comply with radio noise interference reduction requirements.

## 3. MOUNTING CABLE STRAPS.

Cable straps are supported by means of pads, studs, and hangers. Pads are round pieces of steel, usually 9/16 inch in diameter by 3/8 inch thick, drilled and tapped for ANS, right hand, 5/16 inch- 18 threads with class 2 fit. They are welded to the ship's structure so that the cable straps can be screwed in place. Installing pads is easiest when they are drilled and tapped and secured to the cable strap. Spot weld or tack the pads and then remove the cable strap before welding the pad entirely to prevent damage to the strap.

Pads or studs may be used on bulkheads not subject to condensation or moisture. Hangers are used where condensation occurs or where the bulkhead is insulated. Where aluminum bulkheads or overheads are encountered, drilling and riveting or bolting may be necessary to secure the hangers or straps.

No attempt will be made here to outline all the procedures to be followed for all the various conditions one encounters. These are found in BuShips 9-S-3980-L Alt. 27. Some of the more commonly encountered conditions are shown in Figure 9-2 to Figure 9-7.

Studs, attached to the ship by the stud welding process (Fig. 9-8) may be used to support cable straps. Studs are a type of headless machine bolt welded to steel bulkhead or overhead.

**9-20**

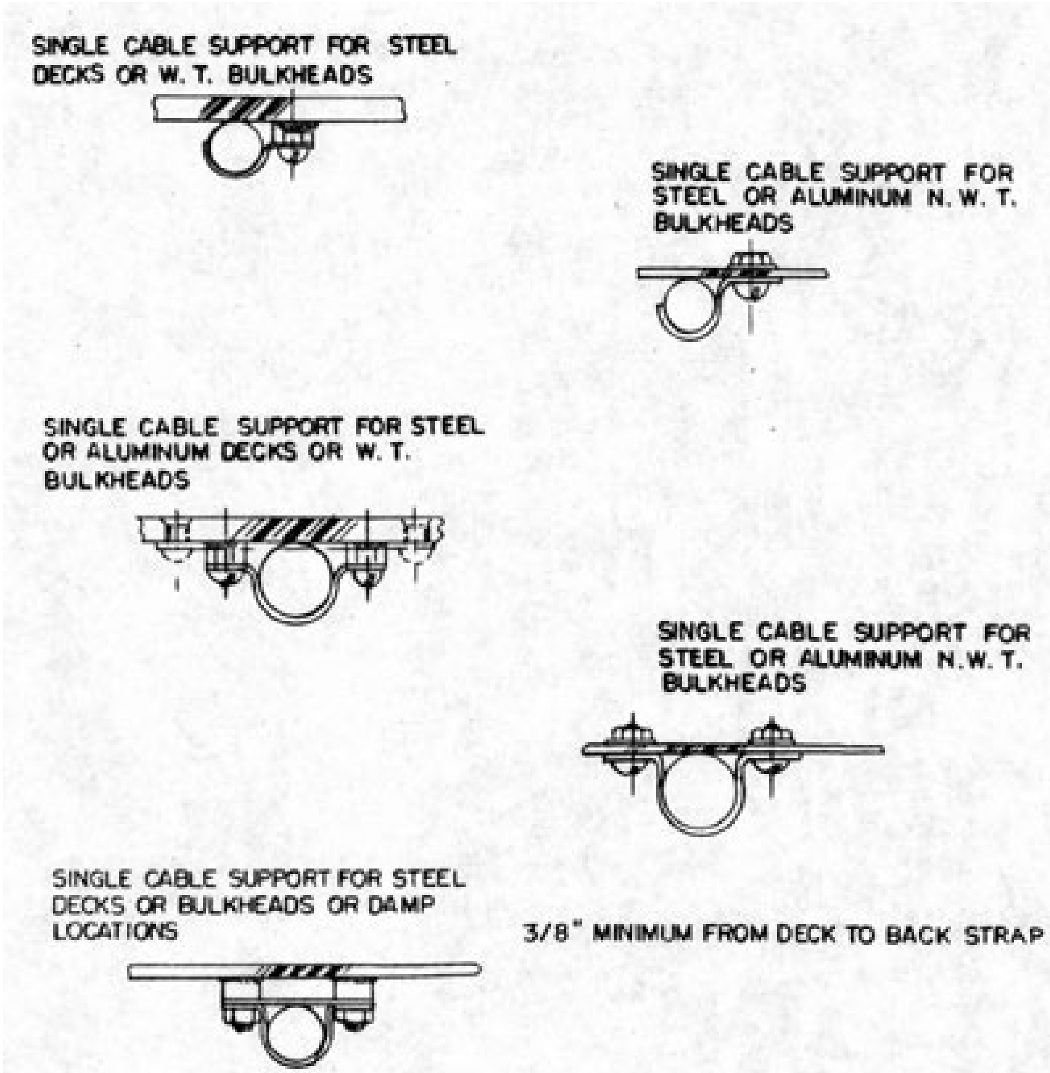
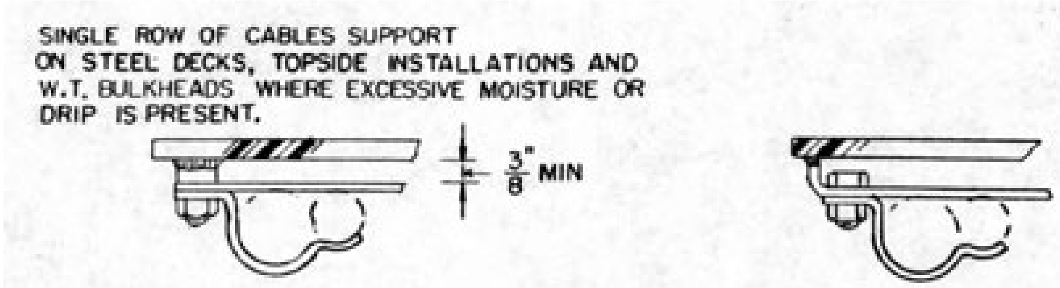
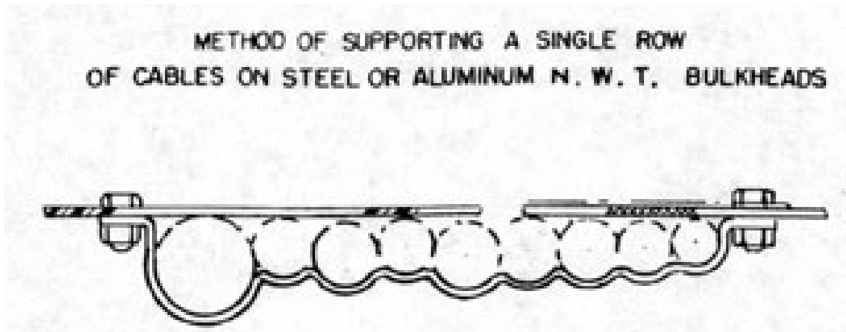



FIGURE 9-2
METHODS OF SUPPORTING SINGLE CABLES

**9-21**



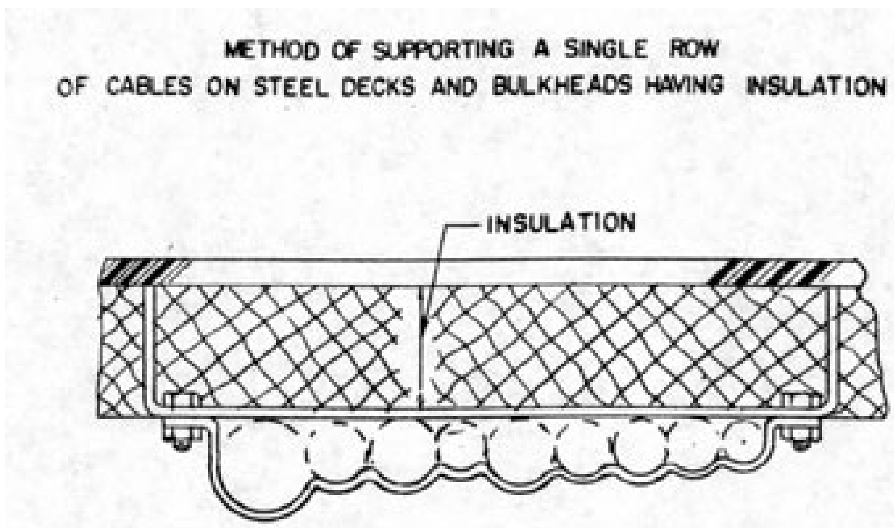




FIGURE 3
METHODS OF SUPPORTING CABLES

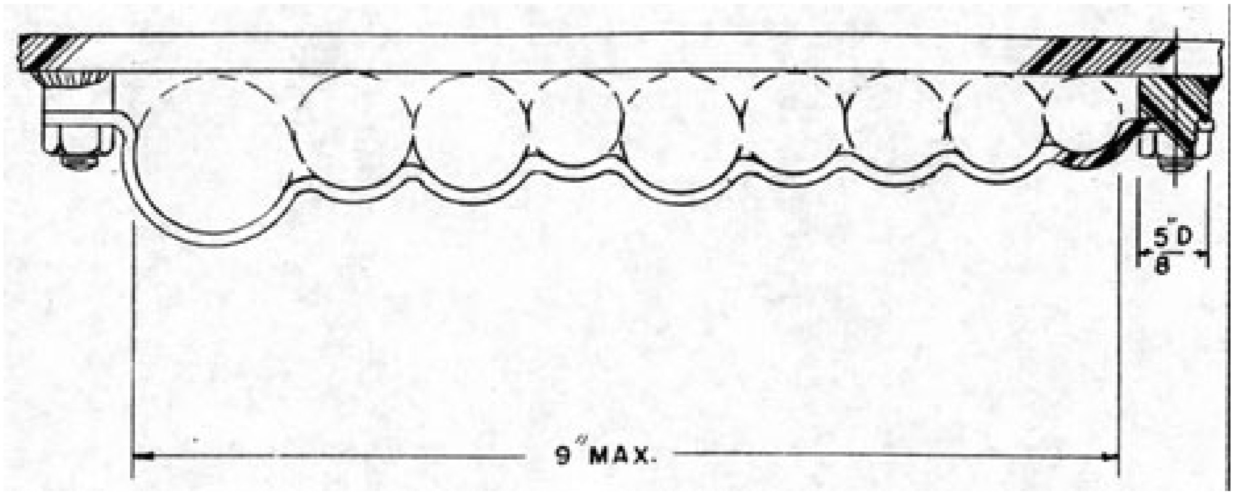



FIGURE 9-4
METHOD OF SUPPORTING A SINGLE ROW OF CABLES
ON STEEL DECKS AND W.T. BULKHEADS

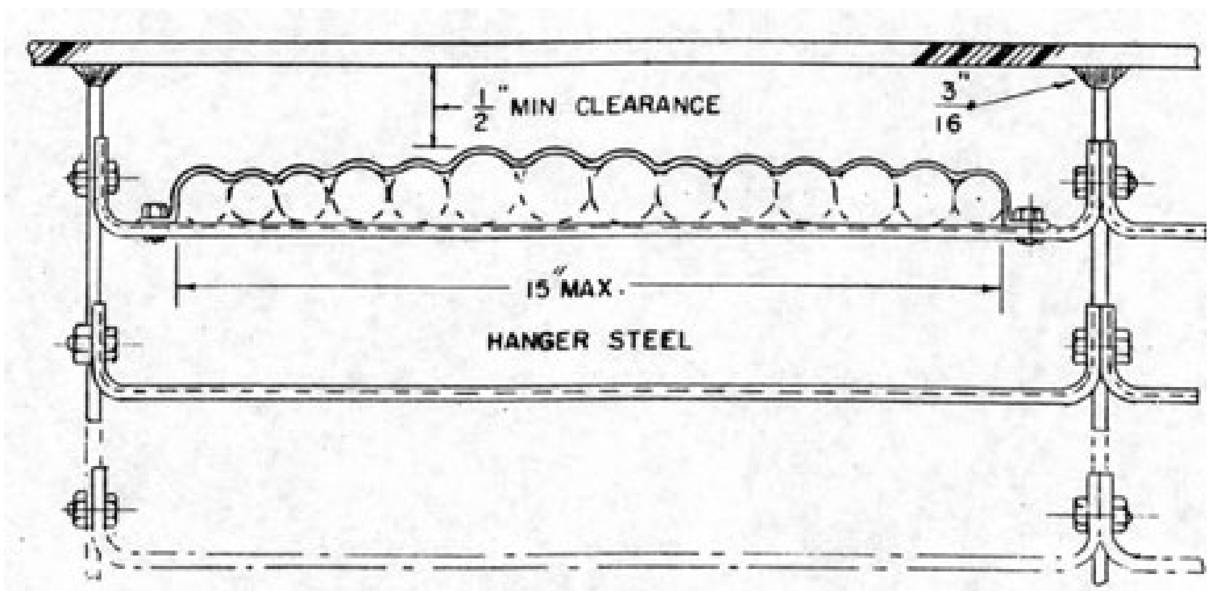



FIGURE 9-5
METHOD OF SUPPORTING MULTIPLE ROWS OF
CABLES ON STEEL DECKS

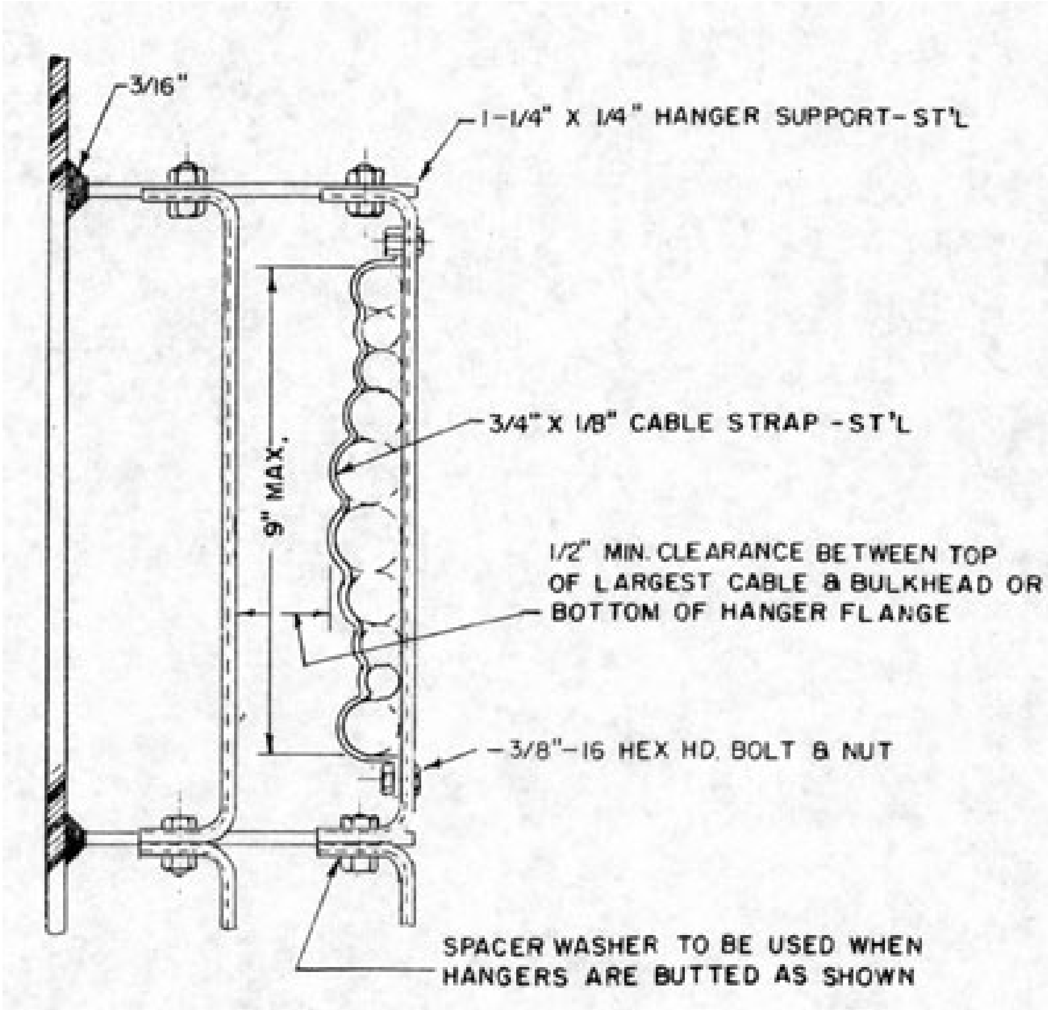



FIGURE 9-6
METHOD OF SUPPORTING TWO ROWS
OF CABLES ON STEEL BULKHEADS

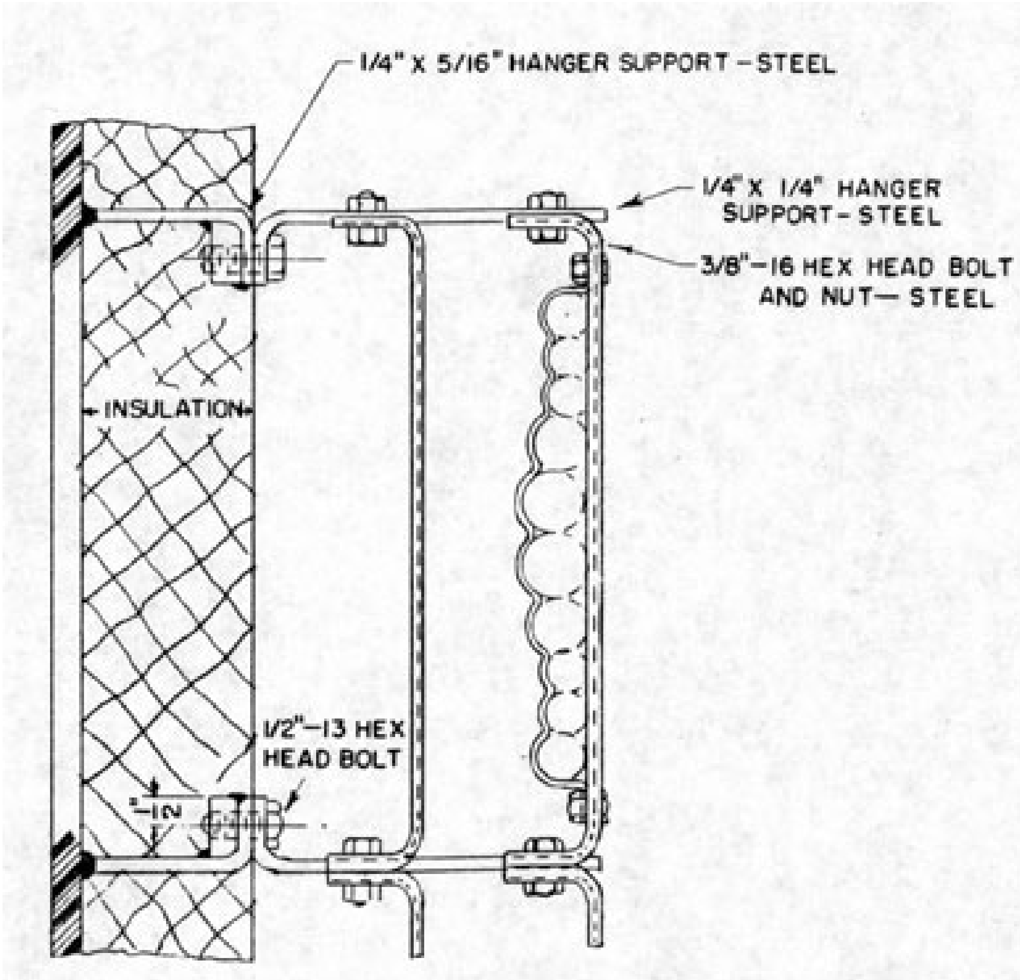



FIGURE 9-7
METHOD OF SUPPORTING TWO ROWS OF CABLES ON STEEL BULKHEADS HAVING INSULATION

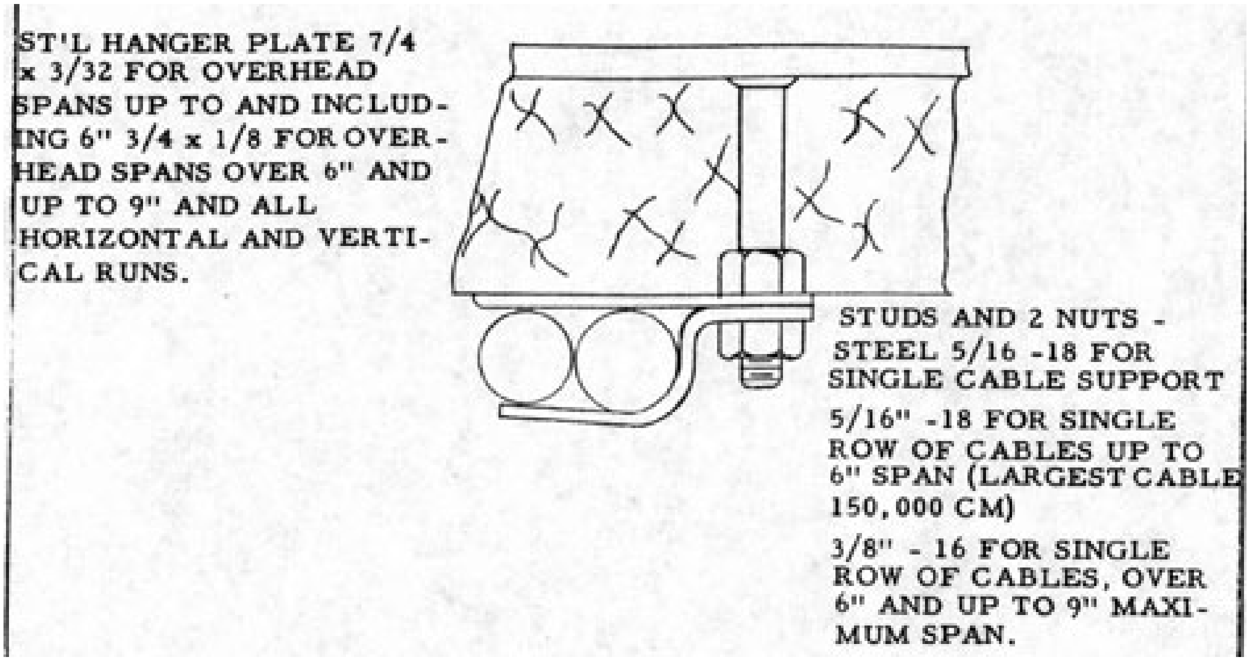



Figure 9-8
STUD SECURED BY THE WELDING PROCESS

**9-26**

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They are available in sizes 1/4 inch, 5/16 inch and 3/8 inch. Hexagonal nuts and lock washers are used with them.

Another type of stud known as the collar stud has a shoulder, which allows the securing nut to be turned down to the shoulder thus giving a spacing between the cable and the bulkhead or overhead.

Before mounting cable straps, make a thorough inspection of all spaces the cable will go through. Avoid obstructions, hot objects, and unventilated spaces if practicable. Locate places where watertight bulkheads must be drilled and mark the location for drillers, allowing space for the welder to work all around stuffing tubes. Inspect both sides of a bulkhead before drilling to check clearance and avoid damage.

Mark the location of hangers, pads, or studs used in the cable run for welder. If the surface over which the cable is to run is insulated, cut away the insulation where the hangers or studs are to be welded, allowing just enough space for the welder to work. If studs are used, it is necessary to grind the steel surfaces to a bright finish before welding. Hanger spacing should not exceed 16 inches center to center. After all the hangers and clamps are in place, the cable is run as described in "Installation in Wireways". When running cables across beams, and in order to avoid obstructions and preserve alignment of the cable run, make use of cable supports (Figure 9-9) and extended cable hangers . When going through decks, a kickpipe (Figure 9-10) will usually be necessary to protect the cable from damage.

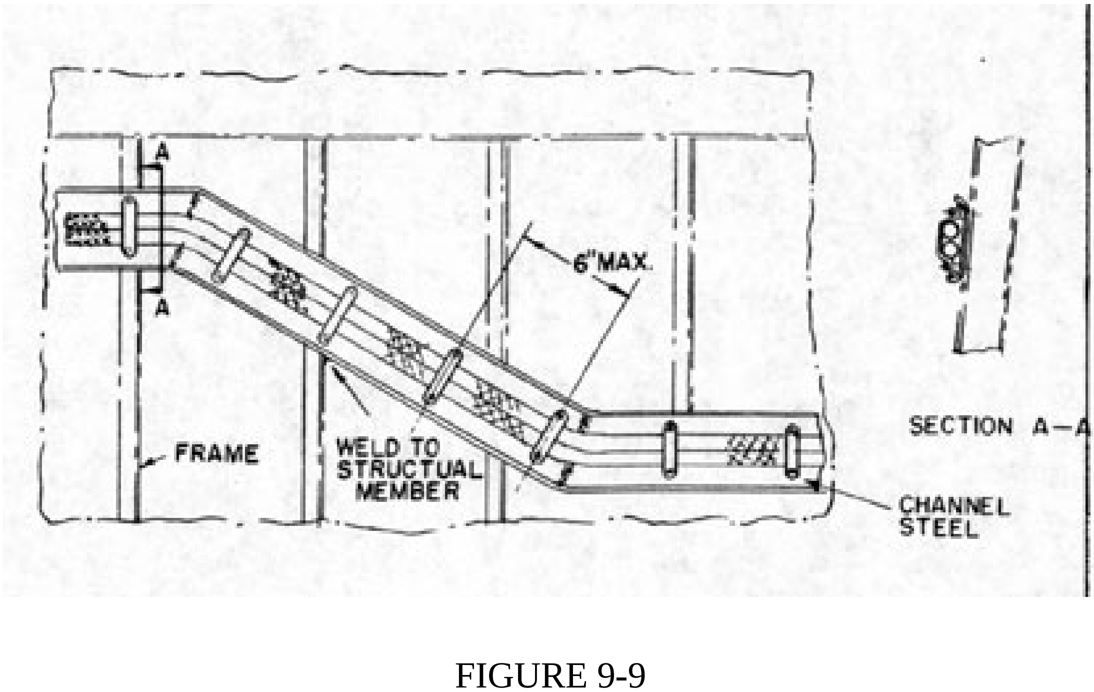


FIGURE 9-9
METHOD OF SUPPORTING CABLE USING CHANNEL

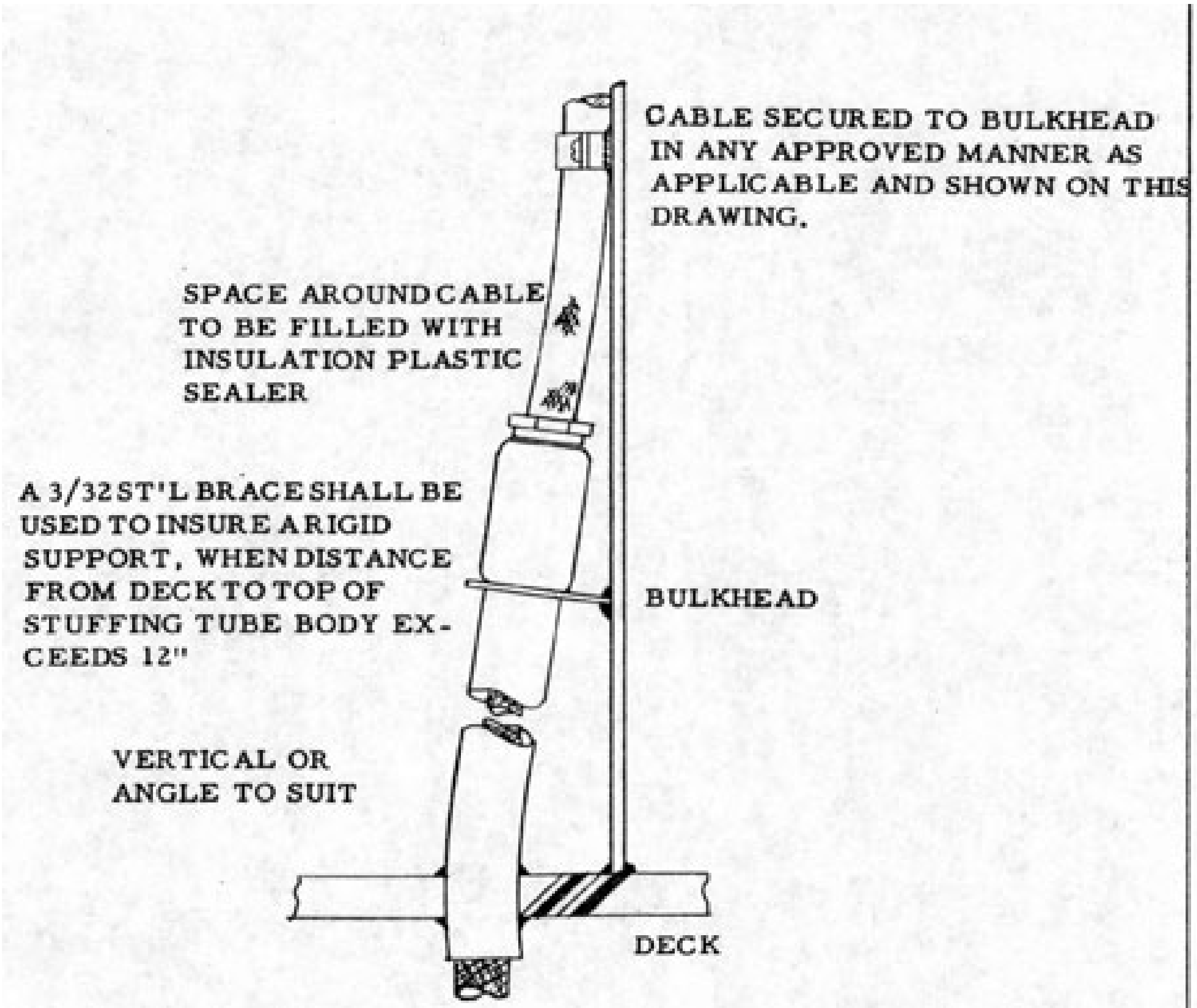


FIGURE 9-10
TYPICAL KICKPIPE ASSEMBLY
CABLE SUPPORTS

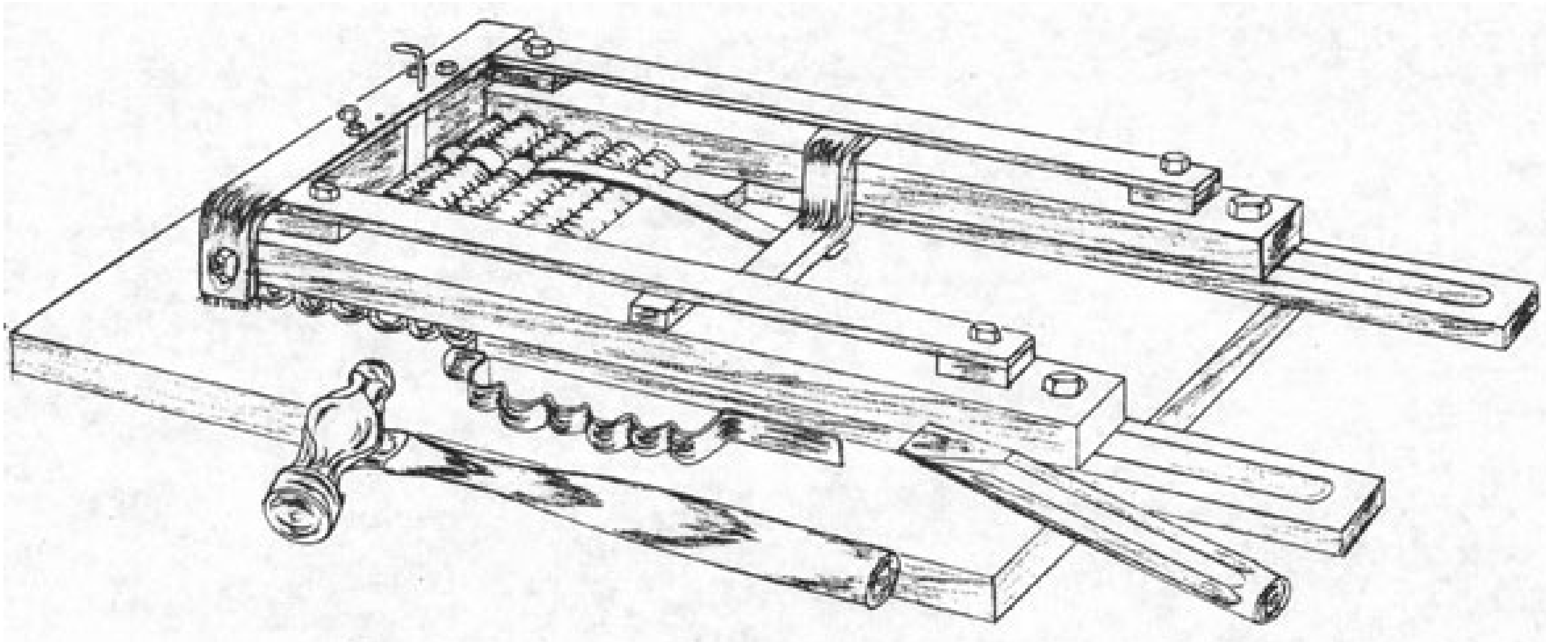

FIGURE 9-11
CABLE STRAP FORMATION

**9-30**

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SECTION 9-4

INSTALLATION IN WIREWAYS

1. INTRODUCTION.

Because cable runs should be as direct as possible, wireways should be planned before the development of deck wiring plans. While this is mainly a function of the design section, some considerations in planning are presented to acquaint the installation worker with some of the problems involved. The plan for wireways should provide for:

a. Protection from battle damage

b. Circuit trunking

c. Protection from excessive heat

Plastic sealer, hacksaw, knife, diagonal cutters, screw driver, side cutters, armor strippers, lacing cord and shuttle.

A spin-tite wrench and box wrench are very useful in tightening down the 5/16 inch - 18 hex machine screw used with pads. Round head machine screws may also be used.

2. HANDLING CABLE.

a. BENDING. - In handling cable, both before and during installation, care should be taken to avoid abrasion and crushing, or sharp bends made without the aid of a mandrel. Such bends are most likely to occur when a cable is taken off a reel or unwound

d. Protection from excessive moisture

e. Protection in hazardous locations

f. Minimum interference with machinery removal

g. Spare wireway area for future expansion

h. Cables to guns and directors

i. Cables away from the magnetic compasses

The greater part of cable installation in wireways is usually done while a ship is still on the ways, with no equipment aboard. This work is handled by the electrical group. However, an understanding of installation methods and practices will benefit the electronic installation men when equipment is added or short runs must be made.

Tools and material necessary for the average cable run are as follows:

Wrench (adjustable, open-end, for stuffing-tube gland nuts)

Black 1 inch friction tape, packing material (see section on stuffing tubes)

from a coil. Sharp "kinks", if pulled on, can ruin that section of cable by causing internal damage to insulation. All bends should be made with a radius no less than the minimum given in the table.

Where cables spread out to enter bulkhead stuffing tubes, the bends should be given a generous sweep to allow for flexibility at this point. Sufficient flexibility should exist to allow for deflection of the bulkhead without subjecting the cables to destructive tension or shearing. Run enough excess cable to permit repairs to be made at cable ends and to avoid cable renewals.

b. LOW TEMPERATURES. - Cables become stiff at temperatures below 35°F and must be handled extra carefully to avoid cracking or rupturing the sheath or the insulation.

Any compartment in which cables are being installed should be heated and the cables should be handled only when their temperature is above freezing.

If cable must be installed in a compartment at 35° F. or below, stow the cable first in a compartment heated to at least 50°F. but not over 120°F. , and leave it there until it is warm enough so that installation in the cold compartment can be completed before the cable cools down.

Cable installations can be made successfully, at or slightly below 35°F. by handling the cable very carefully. While pulling the cable into the wireways, the radius of bend should be no shorter than absolutely necessary.

The part of the cable where a bend is to be made in putting it into its final position should be heated with a portable, warm-air blower. The bend should not have a radius less than the minimum given in the cable bend data tables.

## 3. GROUPING CABLES.

When grouping cables in wire-ways, arrange those types and sizes of cable that can be bent on the shortest radius on the inner side of the cable group, allowing the cables that cannot be bent as sharply to be placed on the outside of the group (Figure 9-12). Avoid grouping together cables which will result in building up of electrical disturbances or interfere with the proper functioning of the electrical circuits involved. All shipboard circuits may be classified as either low level, medium high level, or high level for the purposes of grouping.

Low level circuits are those circuits which normally carry small levels of useful signal (1000 microvolts or less), such as transducer lead-ins.

Medium high level circuits are those which normally carry useful signals in the order of several volts or less such as audio amplifiers.

High level circuits are those which normally carry high levels of power such as ships service power supply.

All low level circuits should be physically removed as far as practicable from high level circuits.

EXAMPLE: Radar pulse cables are causing serious interference trouble on low level cables, such as sonar cables to the transducer. Separation of these circuits is essential to the proper operation of the sonar system.

## 4. LAYING CABLE IN WIREWAYS.

From the reels, cables should be "walked in" cable runs. Only the manual efforts of the installation crew are used to pull cables. Under no circumstances should block and tackle, chain falls, or other mechanical devices be used to pull cables taut.

The sag between hangers should be the same for large and small cables and should be maintained uniform between all hangers in the run. Such sag should not exceed one inch.

Temporary cable straps, made oversize without cable outline, are useful in arranging cables neatly as work along a wireway proceeds. They are installed at positions ahead of those being worked upon and support the cables loosely. Soft baling wire may be used to support cables in hangers temporarily, especially at bends. Permanent straps are installed after the cables are properly arranged with regard to break-offs and separation into two or more wireways. After the cables are located in the wireway, tighten the straps so that they hold the cable but are not so tight as to cause deformation of cables or to prevent lengthwise movement of the cables.

**9-32**

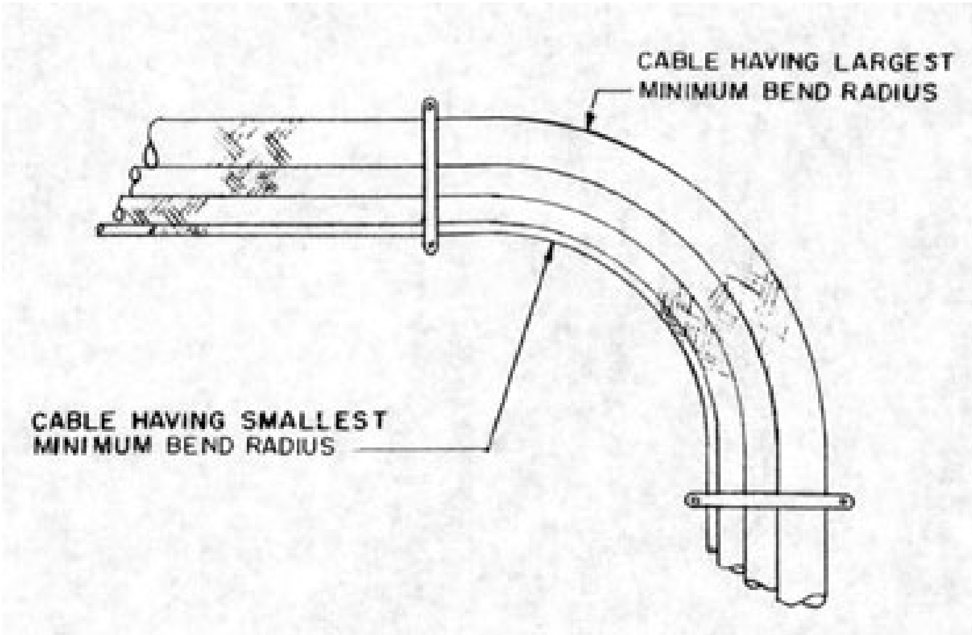


FIGURE 9-12
ARRANGING CABLES IN WIREWAYS

**9-33**

5. PASSING THROUGH BULKHEADS.

a. NWT BULKHEADS. - Where cables pass through non-watertight bulkheads or beams that are 1/4 inch thick or over, no stuffing tubes are used, but the clearance holes should be drilled slightly larger than the cable and the edges of the holes rounded off to prevent chafing of the leads. Where non-watertight beams or bulkheads are under 1/4 inch in thickness, standard or special bushings as shown in Figure 9-13A, 13B, and 13C should be used. On all non-watertight bulkheads, where sharp bends occur in the cables immediately after passing through such holes, standard or special bushings are used.

b. WT BULKHEADS. - When cables pass through W T bulkheads they will feed through W packing stick described in section on tools is recommended. Proper packing methods are described in the section on stuffing tubes.

6. APPLIANCE ENTRANCES.

Where cables enter into vertically installed NWT appliances, avoid entering the appliance from the top. Water should not accumulate in NWT appliances, but condensation can run down a cable entering at the top and cause a failure. If possible enter at the bottom or side. When an entrance at the bottom is made, take care that the cable end is taped and sealed to prevent the entrance of moisture into the interior of the cable (Figure 9-14).

Commercial cable clamps (Figure 9-15) (Greenfield

T stuffing tubes. The usual practice is to stuff and pack the tubes as they are encountered along the cable run. Avoid using a screw driver for packing as this may damage threads and insulation. A tool similar to the Connectors) are widely used where cables enter NWT appliances. These are discussed in the chapter on stuffing tubes.



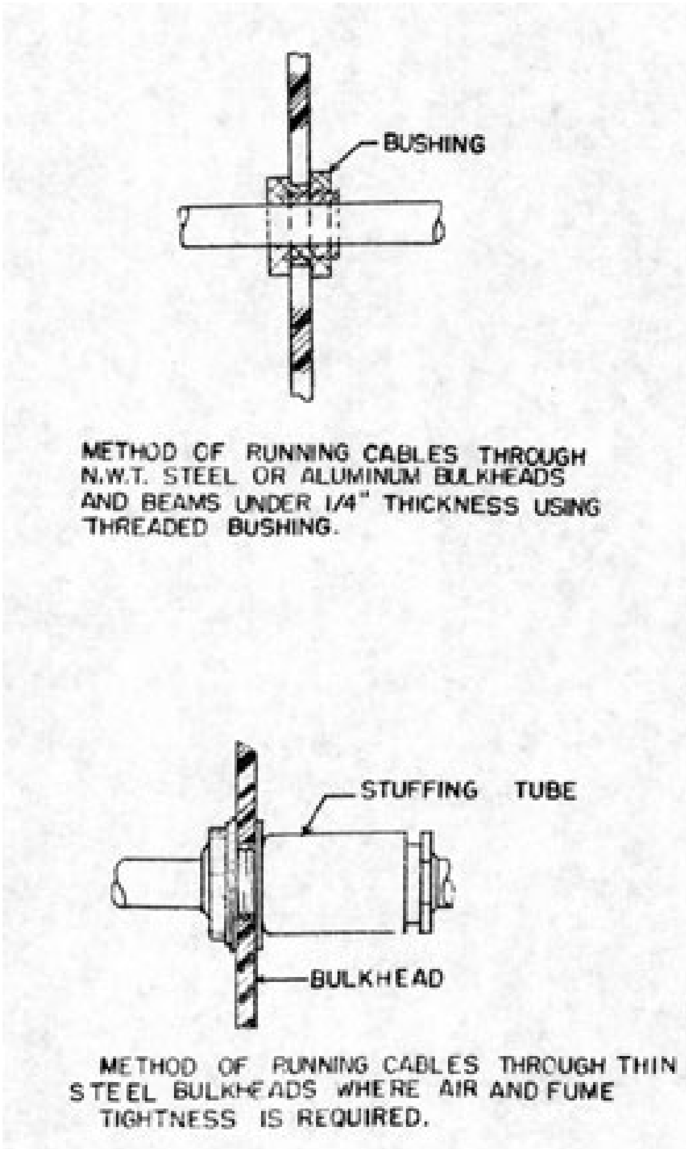


FIGURE 9-13A
METHODS CF RUNNNG CABLES
THROUGH N.W.T. BULKHEADS

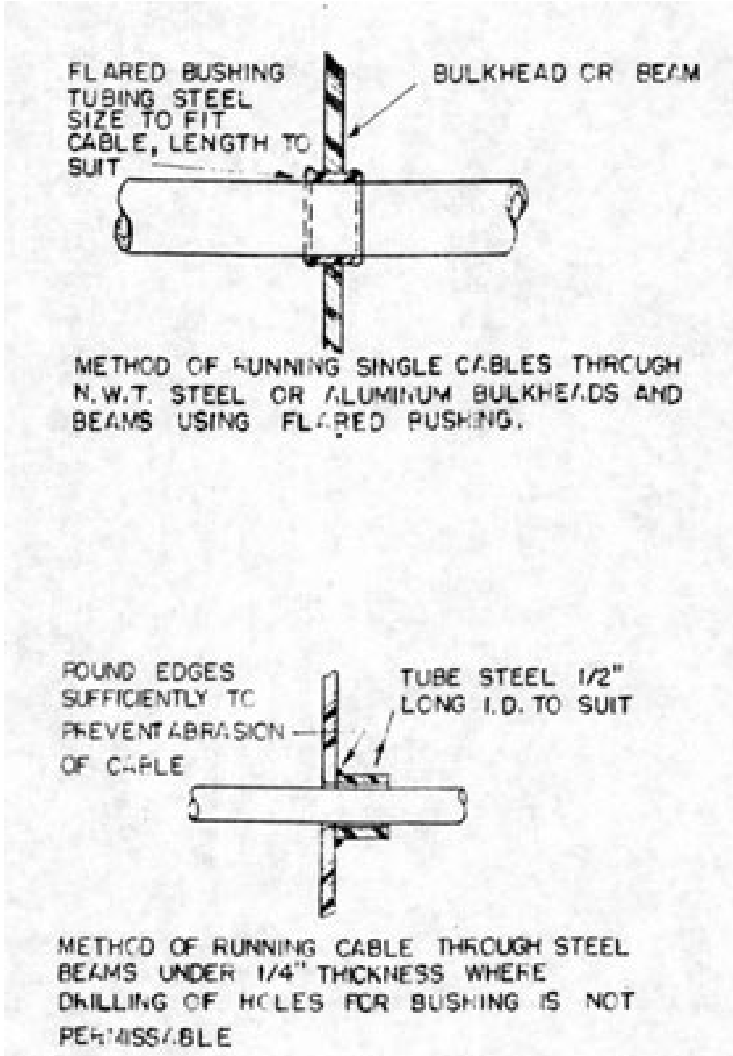


FIGURE 9-13B
METHODS OF RUNNING CABLES
THROUGH N.W.T. BULHEADS

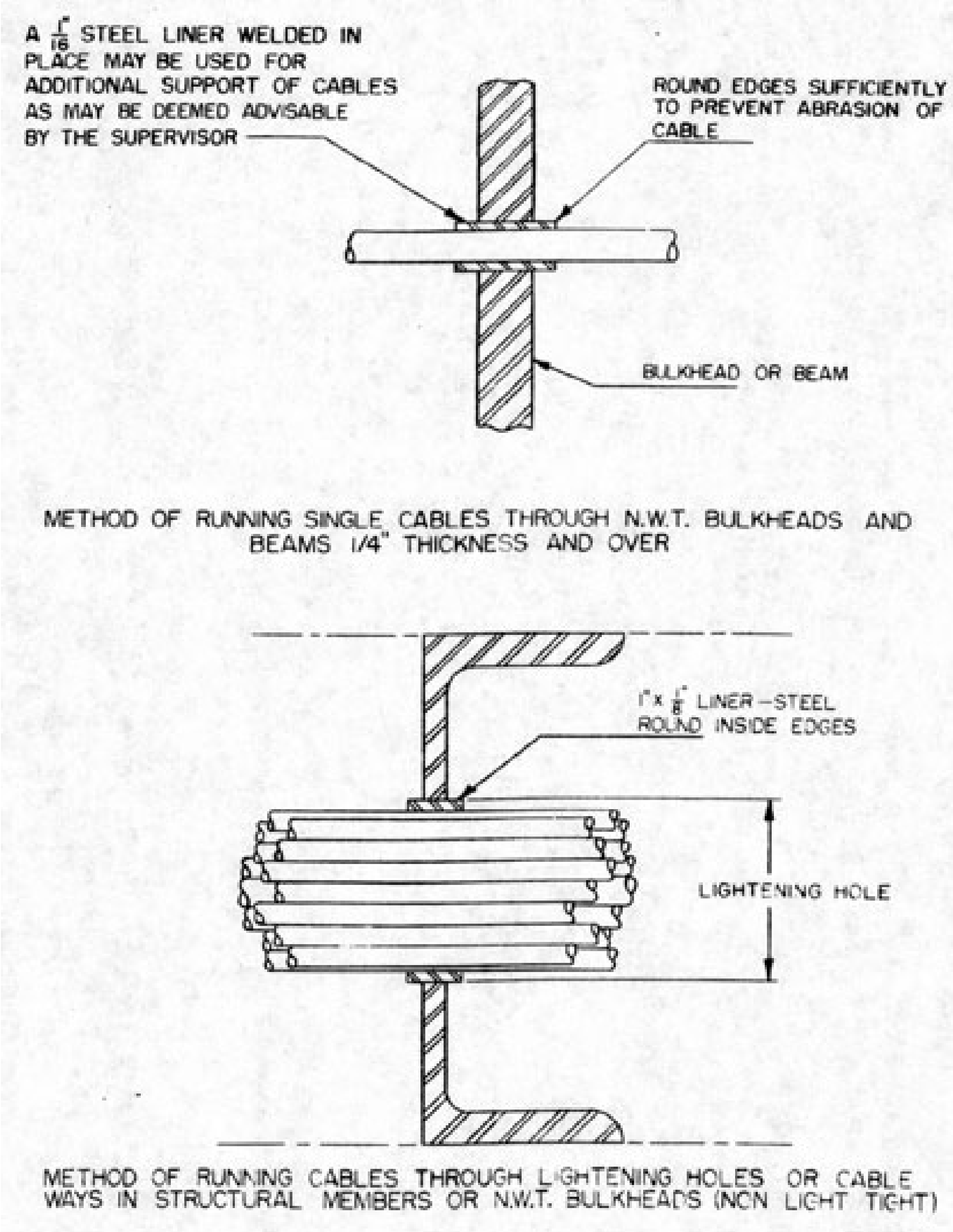


FIGURE 9-131C
METHODS OF RUNNING CABLES
THROUGH N.W.T. BULKHEADS

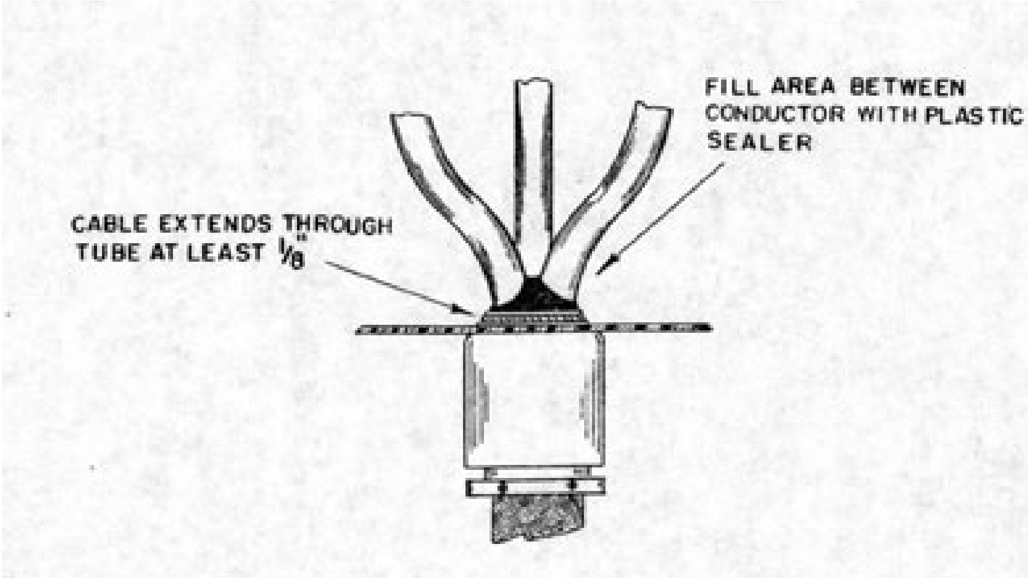


FIGURE 9-14
METHODS OF MAKING UP CABLE ENDS
CABLE ENTERING BOTTOM OF ENCLOSURE

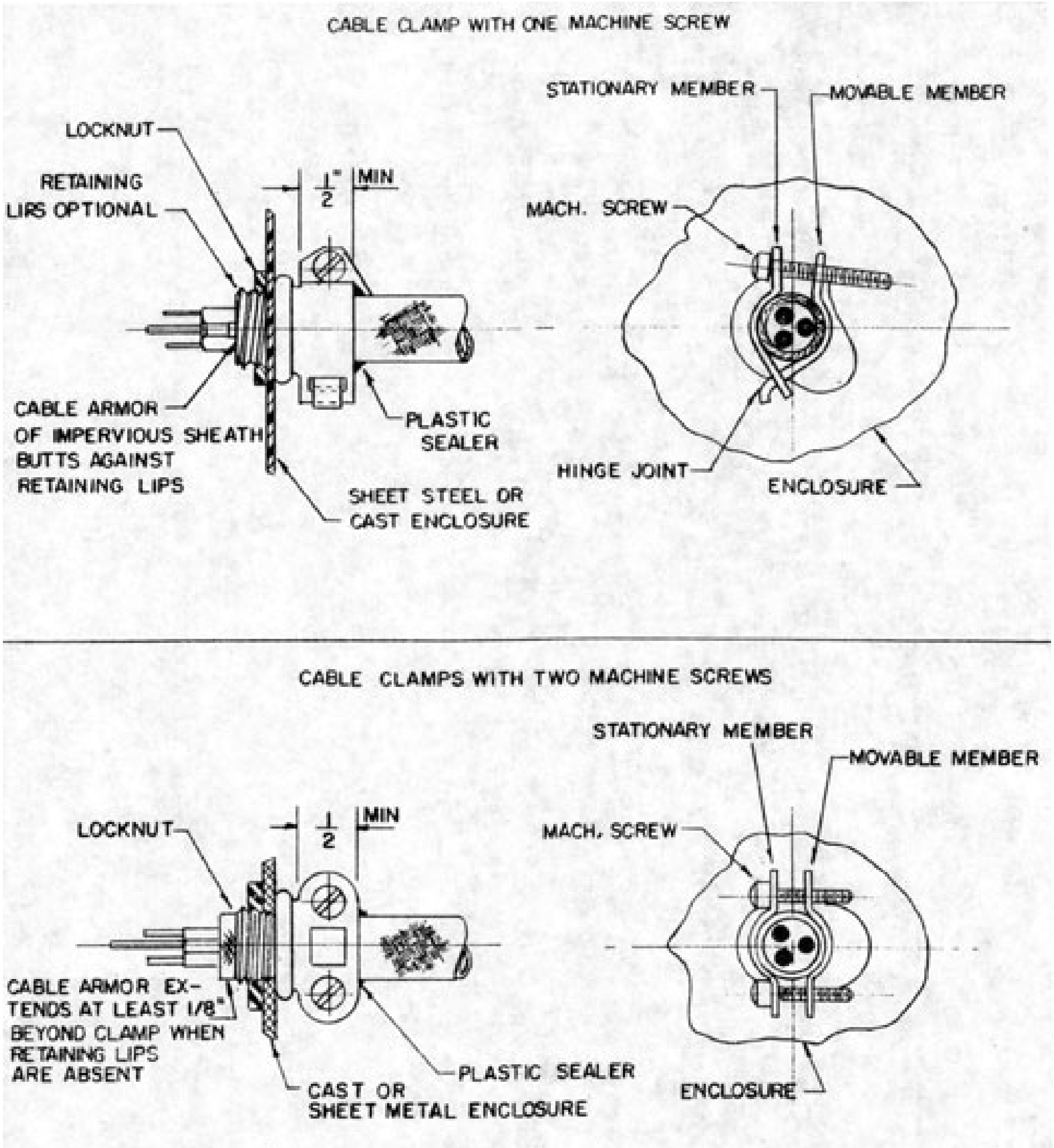


FIGURE 9-15
CABLE CLAMPS-COMMERCIAL TYPE
FORMED SHEET STEEL

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# SECTION 5

# NUMBERING CABLES AND CONDUCTORS

## 1. INTRODUCTION.

All ships cables are identified by metal tags that show the source, relative importance and classification of each cable. Permanently installed ship's cables are tagged as close as practicable to each point of connection, on both sides of decks, bulkheads, and other barriers. The length of cable between cable tags should not exceed 50 feet. Non-vital cables less than 50 feet long and located wholly within the same compartment, so that they may be easily traced, need not be tagged.

## 2. IDENTIFICATION OF CABLES.

| | |
|---|---|
| C | - I. C. leads |
| F | - Ship's service lighting feeders and general power feeders. |
| FB | - Battle power feeders. |
| G | - Fire control circuits. |
| R | - Electronic (radio, radar, and sonar) circuits. |
| XFE | - Emergency lighting and emergency power feeders. |

Feeders that supply power to electronic equipment are identified as is specified for power and lighting circuits, up to the last distribution point preceding the electronic equipment. Then the electronic designations are used on cables from this last distribution point to the electronic loads. Power cables between units of electronic equipment have electronic designations.

## 3. ELECTRONIC CABLE DESIGNATIONS.

Electronic cables are marked as follows:

EXAMPLE: R-RB3

| | |
|---|---|
| R | indicates electronics. |
| RB | indicates an entertainment receiver circuit. |
| 3 | indicates cable number 3 of the entertainment receiver circuit. |

EXAMPLE: 2R-ES7

| | |
|---|---|
| 2 | indicates the second surface search radar circuit on the vessel. |
| R | indicates electronics. |
| ES | indicates a surface search radar circuit. |
| 7 | indicates cable number 7 of the surface search radar. Note that where 2 or more systems with identical circuit letters are installed, the cable designation is preceded by a number. |

## 3. COLOR BANDING.

All vital and semi-vital electronic cables, except branch and sub-branch circuits, have identification tags colored as follows:

**Radio, Radar, Sonar**

| | |
|---|---|
| Vital - | Red |
| Semi-Vital - | Yellow |
| Non-vital - | Gray |

Cables having power system designations are color-banded red when supplying vital I.C. and F. C. circuits and yellow when supplying semi-vital circuits.

5. DEFINITIONS.

VITAL CABLES. -Those, which if cut in action, would disable apparatus absolutely necessary to the fighting effectiveness of the ship.

SEMI-VITAL CABLES. -Those which, if cut in action, would disable apparatus that contributes to the fighting effectiveness of the ship but is not absolutely necessary.

NON-VITAL CABLES. - Those which furnish power to apparatus whose loss would not seriously impair the fighting effectiveness of the ship.

6. CLASSIFICATION.

The following classification lists vital, semi-vital and non-vital electronic, I. C. and F.C. circuits with their circuit letter designations. (See Table 9-3a, 9-3b and 9-3c.

For power circuits, the classifications are shown on the feeder lists. For I. C. and F. C. circuits; the classifications are indicated by a note on the respective isometric wiring diagrams.

7. TAGS.

The tags for marking cable are made of colored soft steel, zinc, or aluminum tape.

Figure 9-16 shows dimensions, shape and installation.

8. CONDUCTOR MARKING.

All active conductors of electronic cables are marked by stamping, or by use of branded synthetic sleeving, where terminals are too small to be stamped. Terminals to be inter-connected should be marked identically.

In addition to its own identifying marker. each conductor is marked with the cable designation of which it is a part. This is done by placing a synthetic sleeve or fiber tag, having the cable designation on the conductor, next to the point where the connection is made within a connection box. Spare conductors of each cable are grouped and identified with their cable designations.

Color coding for individual conductors is shown in Tables 9-4 and 9-5.

**9-41**

| | CIRCUIT LETTERS | VITAL (RED) | CIRCUIT LETTERS | NON-VITAL (GRAY) |
|---|---|---|---|---|
| Radio Communication | R -RA | Radio Transmitting and Receiving Antenna Systems (includes R. F. extension system) | R-RB | Radio Entertained Receiver Circuits (includes both audio and radio frequency distribution circuits) |
| | IR -RC | Transmitter remote control system circuits (also combined transmitter and receiver control circuits) | | |
| | 2R-RC | Receiver remote control system circuits | | |
| | 3R-RC | Teletype circuits | | |
| | R-RR | Cables between units of a receiving equipment | | |
| | R-RT | Cables between units of a transmitting equipment | | |
| Countermeasures | R-CC | Communication countermeasures systems | | |
| (R-C) | R-CR | Radar countermeasures systems | | |
| | R-CS | Sonar countermeasures systems | | |

TABLE 9-3a
ELECTRONIC SYSTEMS

**9-42**

| | CIRCUIT LETTERS | VITAL (RED) | CIRCUIT LETTERS | NON-VITAL (GRAY) |
|---|---|---|---|---|
| Beacons | R-BA | Aircraft Beacon Systems | | |
| (R-B) | R-BC | Radio Beacon Systems | | |
| | R-BR | Radar Beacon Systems | | |
| | R-BS | Sonar Beacon Systems | | |
| | R-BN | Nancy Beacon Systems | | |
| Sonar (R-S) | R-SA | Azimuth Echo-Ranging-listening systems | R-SE | Depth Charge Direction indicators and range estimators |
| | R-SD | Depth Determining Sonar Systems | R-SM | Sonar Monitoring Circuits |
| | R-SK | Scanning Sonar Systems | R-SP | Attack Aid and Auxiliary Systems |
| | R-SL | Sonar Listening Systems | R-SR | Remote Indicator Systems |
| | R-SO | Bathythermograph Systems | R-SU | Underwater Object Locator Systems |
| | R-SQ | Combination Depth (Azimuth Sonar Systems) | | |
| | R-SS | Sounding (Fathometer) Systems | | |
| Search | R-SB | Underwater Telephone Systems | | |
| Radar System | R-EA | Air Search Radar Circuits | | |
| (R-E) | R-EC | CCA System Circuits | | |
| | R-EF | Fighter Director Radar Circuits | | |
| | R-ER | Radar Repeater Circuits | | |
| | R-ES | Surface Search Radar Circuits | | |
| | R-EW | AEW System Circuits | | |
| | R-EZ | Zenith Search Radar Cts. | | |

TABLE 9-3b
ELECTRONIC SYSTEMS

| | CIRCUIT LETTERS VITAL (RED) | | CIRCUIT LETTERS NON-VITAL (GRAY) |
|---|---|---|---|
| Fire Control Radar | R-FB | Guided Missile Fire Control Radar | |
| Systems | R-FG | Heavy Machine Gun Battery Fire Control Radar Circuits | |
| (R-F) | R-FM | Main Battery Fire Control Radar Circuits (6" Guns and Larger) | |
| | R-FS | Double Purpose Battery Fire Control Radar Circuits | |
| IFF | R-IA | Circuits of IFF Equipment Operating in conjunction with Air Search Radar Systems | |
| (R-I) | R-IC | Circuits of Integrated IFF System | |
| | R-ID | Circuits of IFF Equipment Operating in conjunction with Fighter Director Radar Systems | |
| | R-IF | Circuits of IFF Equipment Operating in conjunction with Radar Repeater Systems | |
| | R -IR | Circuits of IFF Equipment Operating in conjunction with Radar Repeater System | |
| | R-IS | Circuits of IFF Equipment operating in conjunction with surface Search Radar Systems | |
| | R-IT | IFF Transponder Circuits | |

TABLE 9-3c
ELECTRONIC SYSTEMS

**9-44**

| | |
|---|---|
| | VITAL CIRCUITS (Light Blue) |
| G | General alarm and chemical attack system |
| GA | Torpedo control systems |
| GE and GEP | Main battery control systems |
| GH and GHP | Antiaircraft control systems |
| GM | Machine gun control systems |
| GJ and GSP | Secondary battery control systems |
| GT | Captain's target designation system |
| JA | Primary battle telephone system |
| LC | Gyro compass system |
| 1LG, 2LG, 3LG and 4LG | Gyro stabilizer motor generators |
| 5LG | Angle gyro system |
| 1MC to 5MC 11MC to 17MC | General and battle announcing systems (where circuit G is incorporated in MC system) |
| | SEMI-VITAL (Green) |
| EP | Telephone and voice tube call bell system (protected calls) |
| IEC and 2EC | Lubricating oil low pressure alarm systems |
| K | Shaft revolution indicator system |
| L | Steering telegraph system |
| | NON-VITAL (Green) Cont'd. |
| 1MB and 2MB | Engine order telegraph systems |
| 1MC to 6MC | General and battle announcing systems where circuit G is not incorporated in MC systems |
| 21 MC and Similar Systems | Intercommunicating type announcing system |
| N | Rudder angle indicator system |
| 1PA to 5PA | Auxiliary gun firing systems |
| PR | Plotting room ready light system |
| QB | Shell hoist latch indicator system |
| QC | Powder hoist interlock system |
| R | Ready light system |
| RA | Intra turret emergency alarm system |
| RE | Turret power elevating indicator system |
| RT | Turret power training indicator system |
| 1U to 5U | Cease firing signal systems |
| IVB to 5VB | Solar signal systems |
| XJ | Supplementary telephone system |
| XGE | Auxiliary main battery control |
| XJA | Auxiliary battle telephone system |
| XL | Auxiliary steering telegraph system |
| X1MB and X2MB | Auxiliary engine order telegraph system |
| XN | Auxiliary rudder angle indicator system |
| Y | Underwater log system |

TABLE 9-3d
INTERIOR COMMUNICATION AND FIRE CONTROL SYSTEMS

**9-45**

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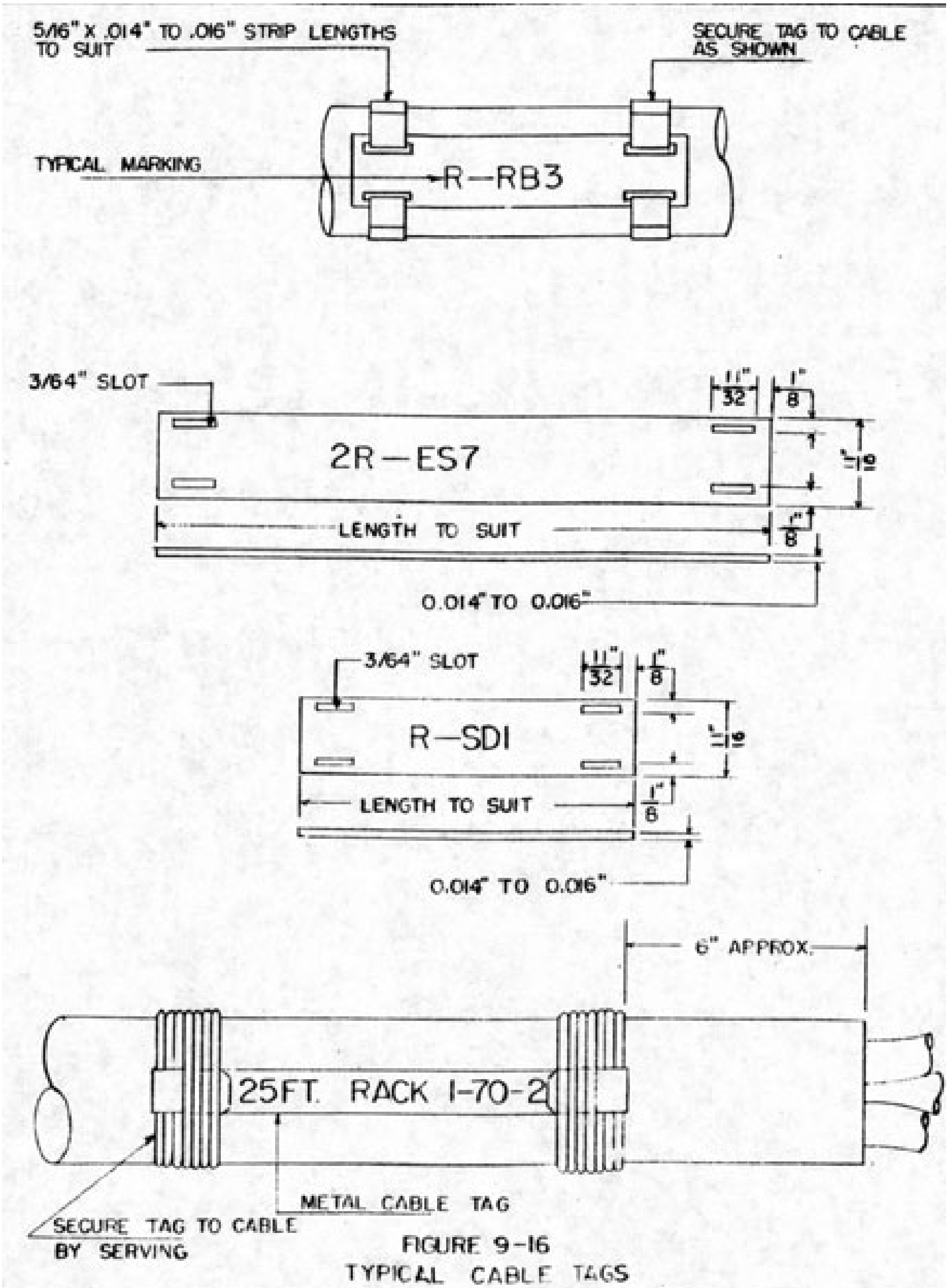


FIGURE 9-16
TYPICAL CABLE TAGS

**19-46**

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## COLOR IDENTIFICATIONS

| Power System | Cable Type | Phase or Polarity | Color or Code |
|---|---|---|---|
| 3 ph. a.c. | 3 cond. | A<br>B<br>C | Black<br>White<br>Red |
| | 2 cond. | AB | A = Black<br>B = White |
| | | BC | B = White<br>C = Black |
| | | AC | A = Black<br>C = White |
| 3 ph. d.c. | 3 cond. | +<br>±<br>- | Black<br>White<br>Red |
| | 2 cond. | + and ± | + Black<br>+ White |
| | | ± and - | ± White<br>- Black |
| | | + and - | + Black<br>- White |
| 2-wire d.c. | 2 cond. | +<br>- | Black<br>White |

Note 1. - The conductor to be used as the ground conductor, in cables where this is required, in any system, shall be the red conductor in 3-conductor cables and the green conductor in 4-conductor cables.

Note 2. - The ±, or neutral, polarity, when it exists, shall always be identified by the white conductor. This white conductor shall always be connected to the screw shell of lighting unit sockets to reduce to a minimum the shock hazard to personnel.

**9-47**

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COLOR CODE USED IN MARINE ELECTRICAL
I. C. and F. C. CABLES NAVY TYPE

| Wire No. | Base Color | Tracer Color | Tracer Color |
|---|---|---|---|
| 1 | Black | | |
| 2 | White | | |
| 3 | Red | | |
| 4 | Green | | |
| 5 | Orange | | |
| 6 | Blue | | |
| 7 | White | Black | |
| 8 | Red | Black | |
| 9 | Green | Black | |
| 10 | Orange | Black | |
| 11 | Blue | Black | |
| 12 | Black | White | |
| 13 | Red | White | |
| 14 | Green | White | |
| 15 | Blue | White | |
| 16 | Black | Red | |
| 17 | White | Red | |
| 18 | Orange | Red | |
| 19 | Blue | Red | |
| 20 | Red | Green | |
| 21 | Orange | Green | |
| 22 | Black | White | |
| 23 | White | Black | Red |
| 24 | Red | Black | White |
| 25 | Green | Black | White |
| 26 | Orange | Black | White |
| 27 | Blue | Black | White |
| 28 | Black | Red | Green |
| 29 | White | Red | Green |
| 30 | Red | Black | Green |
| 31 | Green | Black | Orange |
| 32 | Orange | Black | Green |

| | | | |
|---|---|---|---|
| 33 | Blue | White | Orange |
| 34 | Black | White | Orange |
| 35 | White | Red | Orange |
| 36 | Orange | White | Blue |
| 37 | White | Red | Blue |
| 38 | Brown | | |
| 39 | Brown | Black | |
| 40 | Brown | White | |
| 41 | Brown | Red | |
| 42 | Brown | Green | |
| 43 | Brown | Orange | |
| 44 | Brown | Blue | |

TABLE 9-5
NAVY STANDARD COLOR CODE FOR CONDUCTORS



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## SECTION 6

## PREPARING FOR INSTALLATION

### 1. INTRODUCTION.

The cable for a piece of equipment has been installed in the wireways and is run to the equipment. The job now is to tie it into the equipment. Assume that the cable is to enter the equipment through a stuffing tube. The first consideration is the proper length of cable; it should be made somewhat longer than just enough to reach the connection point.

Form the cable run from the last cable strap to the equipment by hand, allowing for a clean sweep and enough slack at the stuffing tube. This last allowance is for the conductor run inside the equipment; here, good judgment must be used. Determine whether the conductor goes directly to

### 2. REMOVING THE ARMOR.

Form the cable as it is to be run into the stuffing tube and carefully estimate where the cable should come through the tube. Mark this position with a piece of friction tape. (Figure 9-17). The tape serves to seize the armor to prevent unraveling and holds down the armor while cutting; in addition, it serves a marker.

The actual cutting of the armor may be done with diagonal cutters or with armor strippers. Strippers, when available, are capable of doing a neat, fast job (See tool section), although care must be used in working knife blade adjustments on these tools. Most installation men use diagonal cutters. The quality of the work done with diagonal cutters

its connection or whether it forms a laced cable and breaks off. Determine the longest conductor run in the laced cable, and add approximately 2 1/2 times this length to the length already determined up to the stuffing tube. This safety factor covers mistakes in attaching lugs or allows for re-routing. It is desirable to have a surplus so as to avoid cable renewals in the event of repairs. In applications where trouble may be anticipated, as in outside submarine wiring, allow approximately four feet additional slack in the cable run to avoid cable renewals, especially where the cable run is long. The cable length is now known and cut. The next step is to remove the armor.

depends, to a great extent, upon experience; an inexperienced man may easily cut through insulation and spoil a cable.

Method of cutting armor is as follows:

The cut may be taken either just in front of the tape marker or within it. By cutting just in front of the marker, the worker can closely watch his cut and avoid cutting insulation. The frayed edges of the armor can then be trimmed away. When cutting within the tape marker, the tape serves to hold the frayed edges down, but care must be used to avoid cutting the insulation. The armor is cut around the circumference of the cable (Figure 9-18).

**9-49**

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When the length of armor to be removed is not too great, it may be worked off without further cutting, but in some cases the armor must be cut lengthwise

for easy removal. The important thing to remember in cutting the armor is to avoid cutting the insulation, since this may let the frayed armor edges penetrate the cable and cause grounding.

**9-50**

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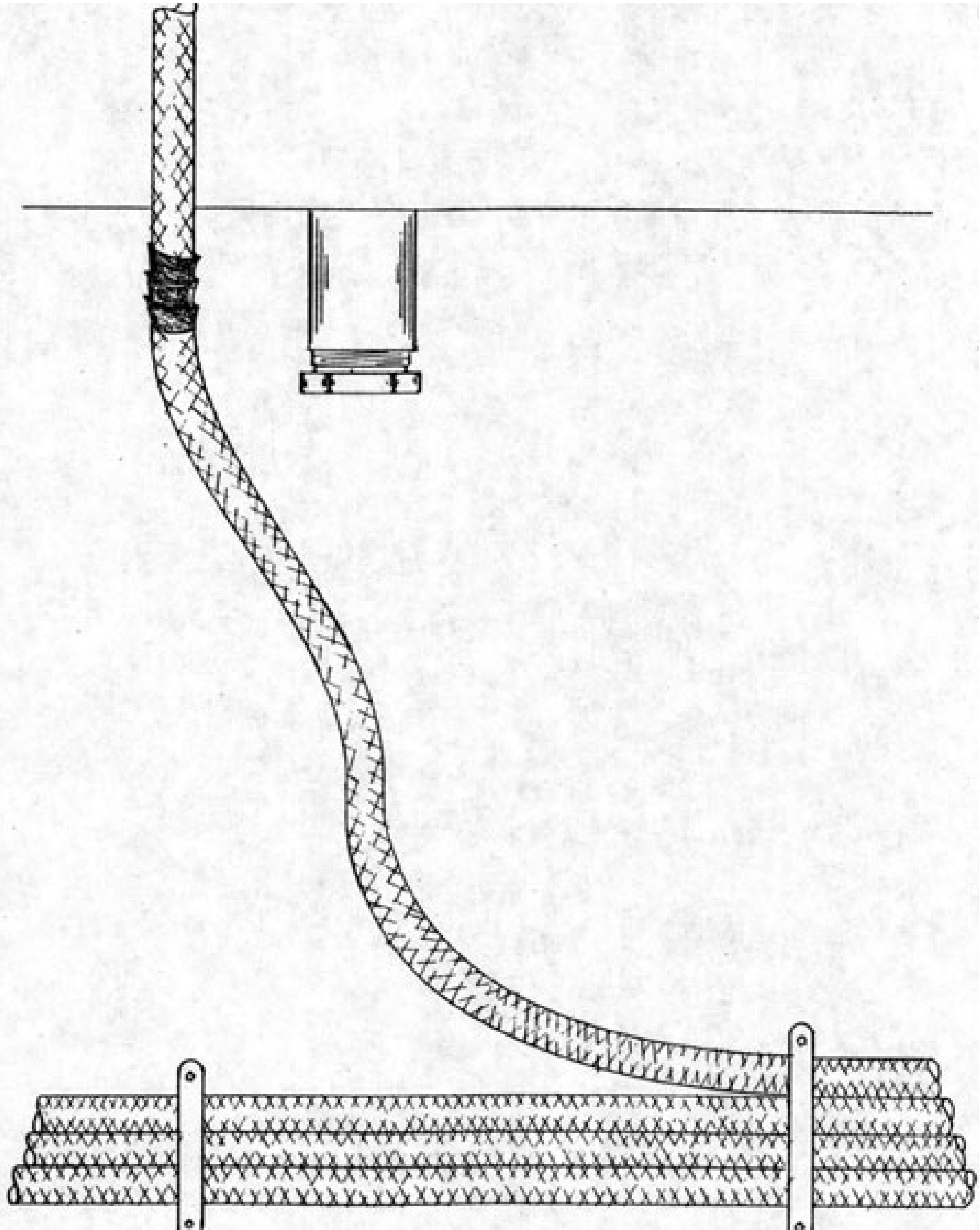

FIGURE 9-17
REMOVING ARMOR FROM CABLE

FIGURE 9-17
REMOVING ARMOR FROM CABLE

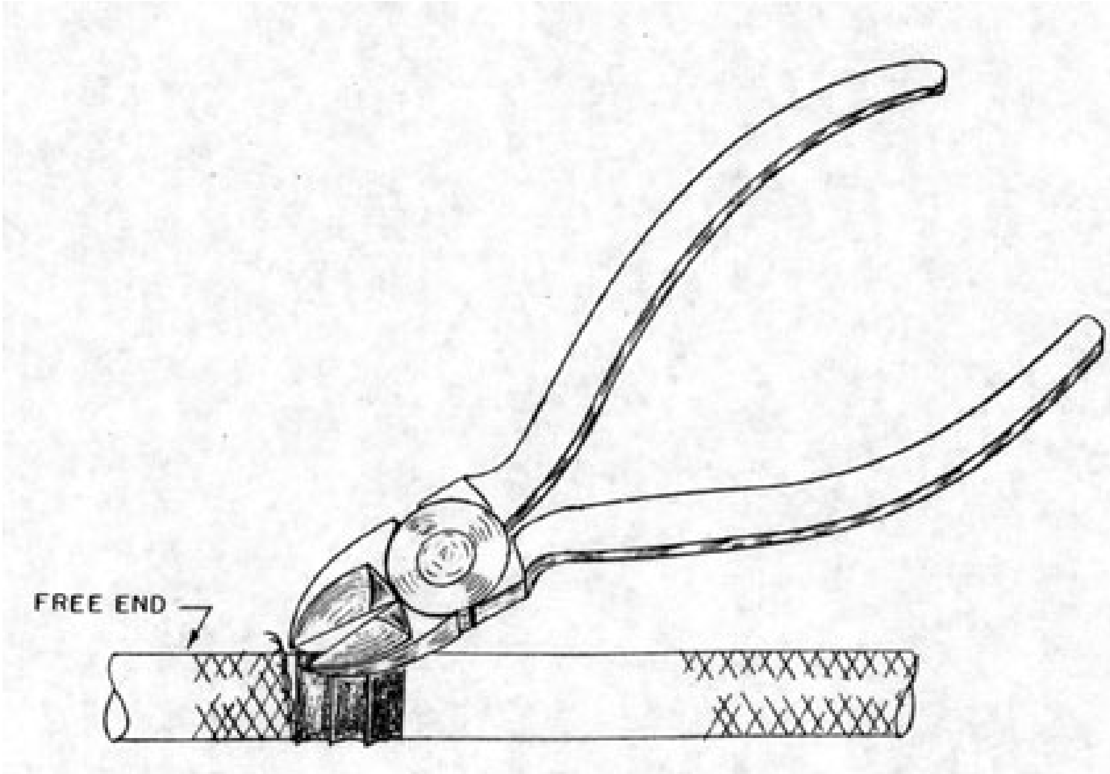


FIGURE 9-18
REMOVING ARMOR FROM CABLE

**19-52**

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3. STRIPPING INSULATION.

After the armor has been removed, start to remove the insulation at a distance of approximately 1/2 inch from where the armor terminates (Figure 9-19).

The following procedure is recommended in stripping the insulation:

First, if one end of the cable is not secured, place the end in a vise or have another man hold the cable. Put a bend in the cable and carefully ring the insulation (Figure 9-20) taking care to cut only the insulating jacket and not into the insulation of individual conductors. With the knife blade at an angle, start cutting a strip lengthwise, approximately 1/2 inch wide and long enough to 9-21 and 9-22). Pull down on the cut with the side cutters. This will form a 1/2 inch strip, and after stripping approximately 4 inches, the remainder of the strip can usually be removed by hand (Figure 9-23).. It is an easy matter to peel off the remaining insulating jacket and to trim off the filler and threads of insulation with a pair of scissors or diagonal cutters.

The Jones cable stripper may be used to perform all of these operations very efficiently. Detailed instructions on the use of this stripper are included in chapter 3 - Hand Tools. The Huff cable stripper (See Chapter 3) can be used only on lengthwise cuts.

allow side cutters a grip on the insulation (Figure



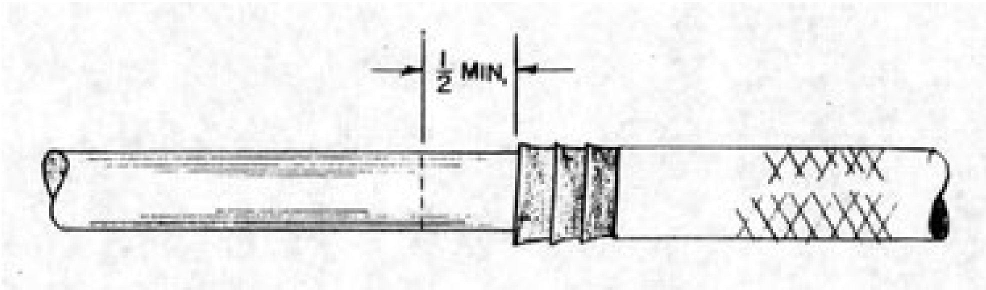


FIGURE 9-19
REMOVING INSULATION FROM CABLE

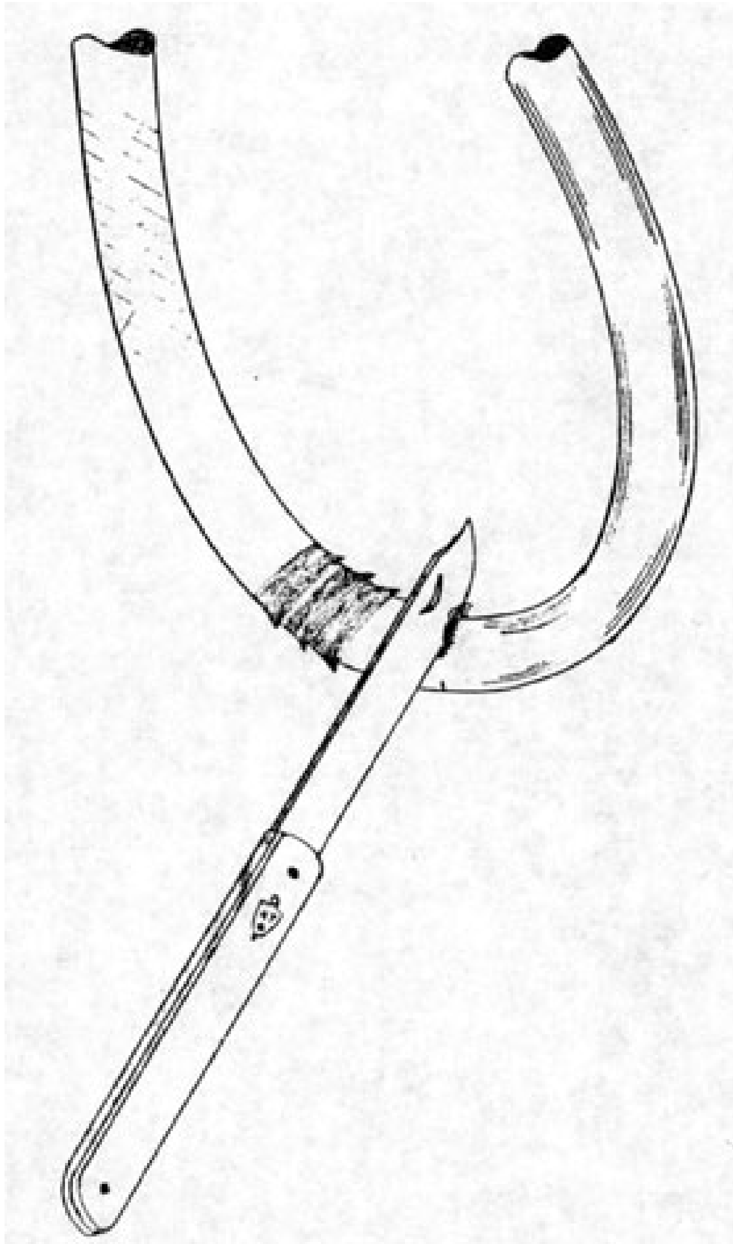

FIGURE 9-20
REMOVING INSULATION FROM CABLE

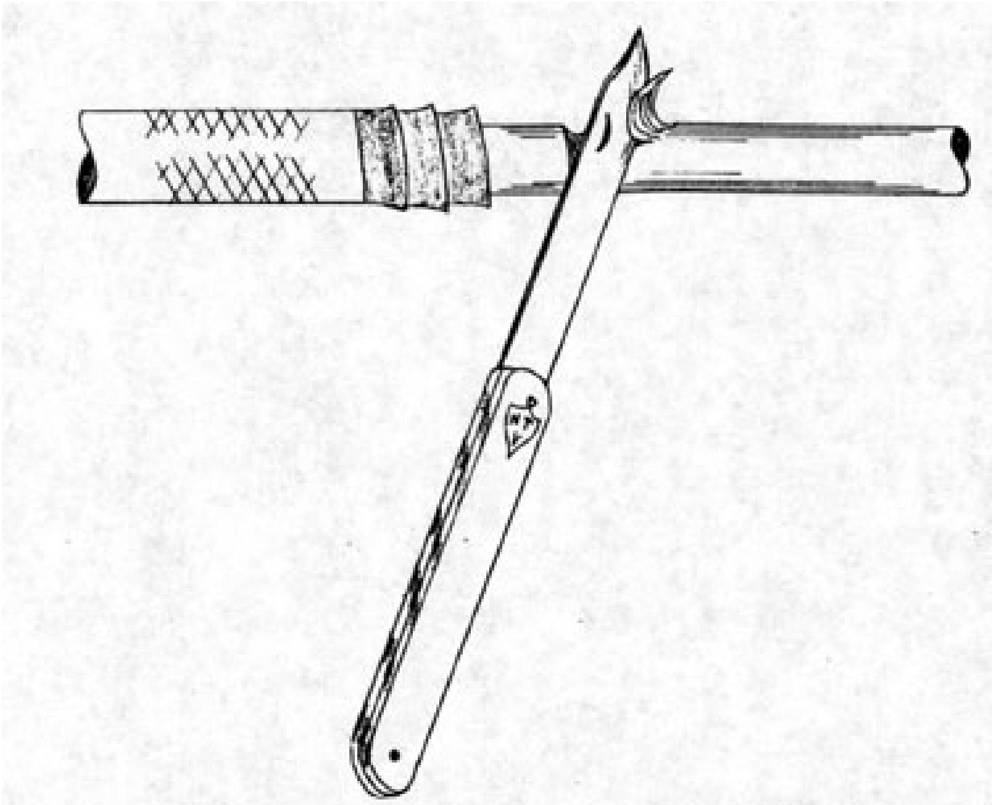

FIGURE 9-21
REMOVING INSULATION FROM CABLE

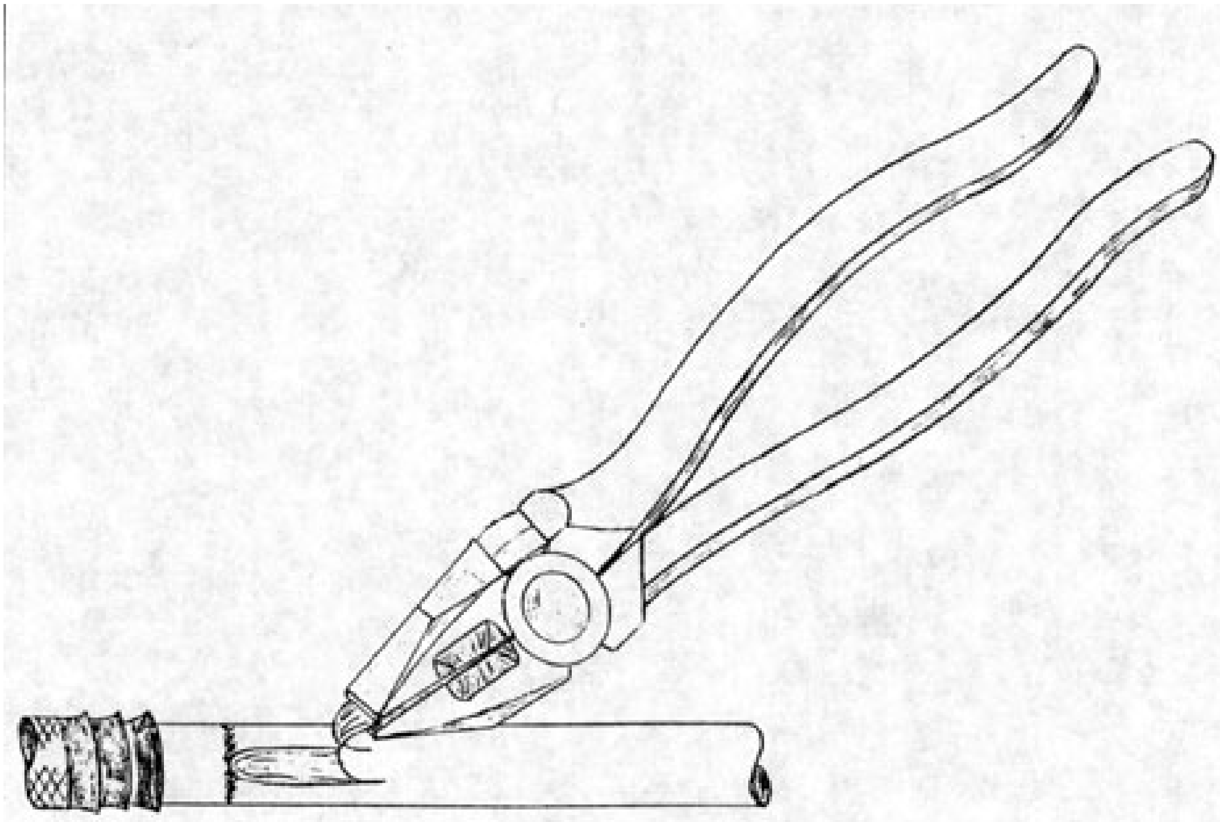

FIGURE 9-22
REMOVING INSULATION FROM CABLE



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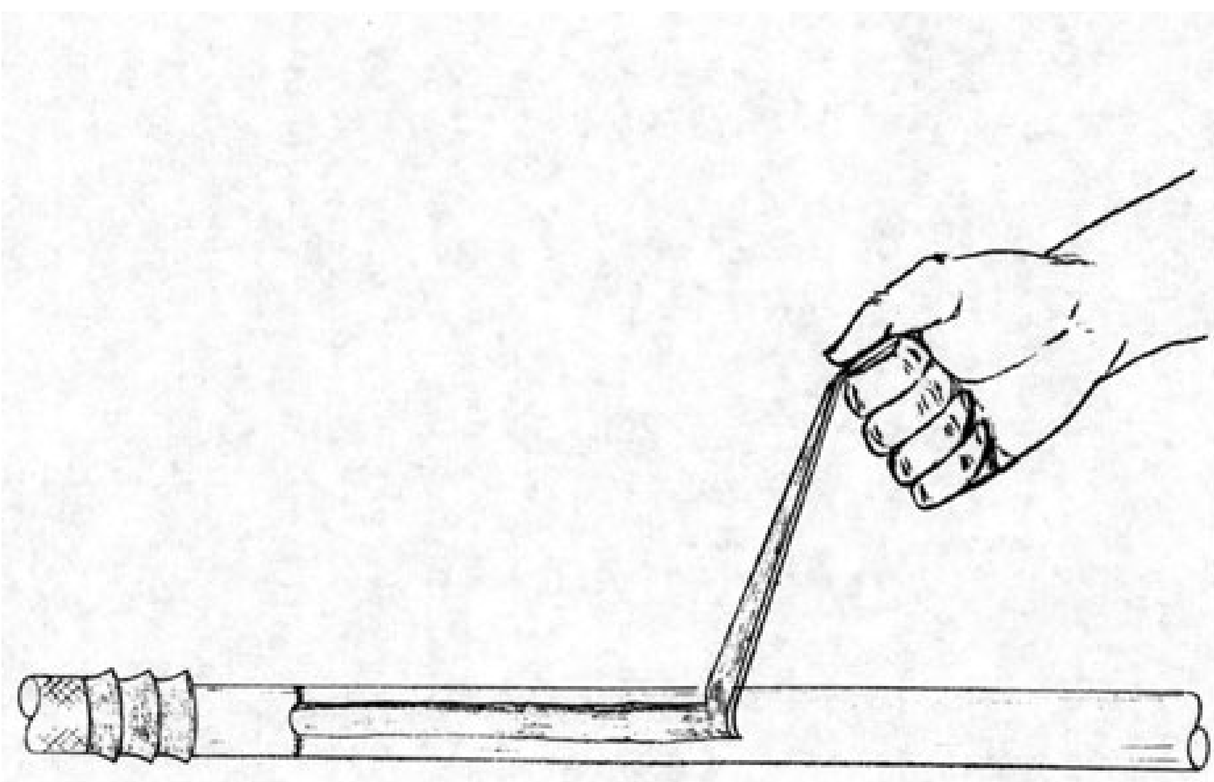

FIGURE 9-23
REMOVING INSULATION FROM CABLE

**9-58**

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4. END SEALING.

End sealing of the cable depends upon its application, but good workmanship demands a neat seal of some sort. In some instances the cable end is served, but friction tape or varnished cambric tape may be used to quick advantage to provide a neat job. (Figures 9-24 and 9-25). A coat of air-drying varnish is usually applied over the tape.

In submarine applications where pressure-proof requirements must be met, particular attention must be paid to end sealing, since improperly sealed cables may act as conduit when exposed to pressure.

The Rubber Laboratory at the Portsmouth Naval Shipyard has developed an improved method for applying molded seals at the ends of portable cables and molded packing between the ends of cables where needed for passing a cable through a watertight bulkhead (submarine applications). The molding compound makes a satisfactory bond with both the cable sheath and the insulation on the cable conductors. Figures 9-26 to show the various arrangements and parts for commonly used cables, taken from BuShips plan #9000-S-6202-73903.

Figures 9-26 to 9-30 give dimensions and typical arrangement for tube sizes A to E. Note that type SRIB (single conductor, resin insulated, braid) and SHFS (single conductor, heat and flame resistant, switchboard) are used to bring the individual conductors out of the molded packing. Note that the continuity of shields where they appear, as for TTRSA types is maintained.

There are no general requirements for end sealing electronic cables terminating at electronic equipment or for end sealing individual conductors. BuShips plan, 9-S-5357-L is not

The Portsmouth Naval Shipyard uses two methods for end sealing individual conductors. One method is used for pressure-proof applications and involve s the use of rubber tape and a rubber cement. The other is used for watertight applications and involves the use of glass fiber tape and air drying varnish.

In this first method, the conductor is stripped and lug is placed on. The rubber sheath is then roughed with a knife for a length of approximately 3/4". No solvents are needed to clean the conductor. Apply B. F. Goodrich "Vulcalock" cement, Navy Stock No. (L) 213-52-C1413 over the barrel of the lug and back 3/4" over the conductor sheath.

"Vulcalock" is used since it stays in liquid form during storage, while other types invariably solidify with shelf life. After applying one coat of cement, allow from 5 to 10 minutes for the cement to get tacky. Approximately 5" of electrical rubber tape (3/4" wide) is cut and split in two lengthwise. Apply a coat of cement to the tape and allow this to get tacky also. The rubber tape is then wound over the conductor, down over the barrel of the lug and then back over the conductor with a half lap. This assembly seals itself and will not delaminate.

In the second method, the lug is placed on as before and Glass Fiber Tape, (1"x .007")Navy Stock No. 17-1-2645-80, is secured to the conductor sheath with Glass Fiber Line (Navy Stock No. 17-12643-145). The line is terminated as in a lace. The tape is wound over the conductor, down the barrel of the lug and back over the conductor with a half lap. Then this end of the tape is secured with the glass fiber line. Then apply a light coat of air-drying varnish. Any type of air-drying varnish, including glyptal, may be used. This end seal is oil resistant and has very good high temperature characteristics when used with the reduced diameter cables.

applicable because of the crimp lug employed. However, it is important that individual conductors be properly end sealed in submarine applications.



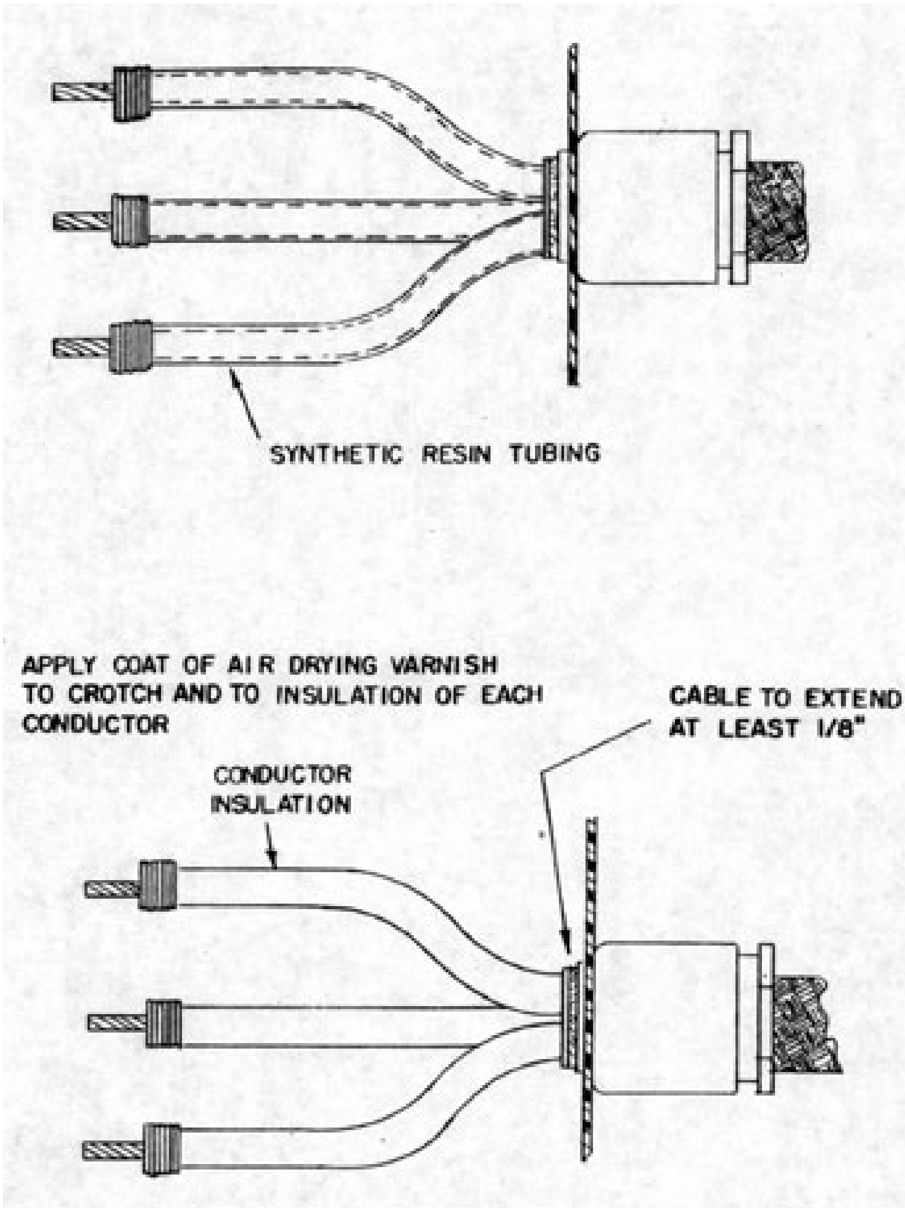


FIGURE 9-24
METHODS OF MAKING UP CABLE ENDS
ENCLOSED EQUIPMENT W.T. AND N.W.T.

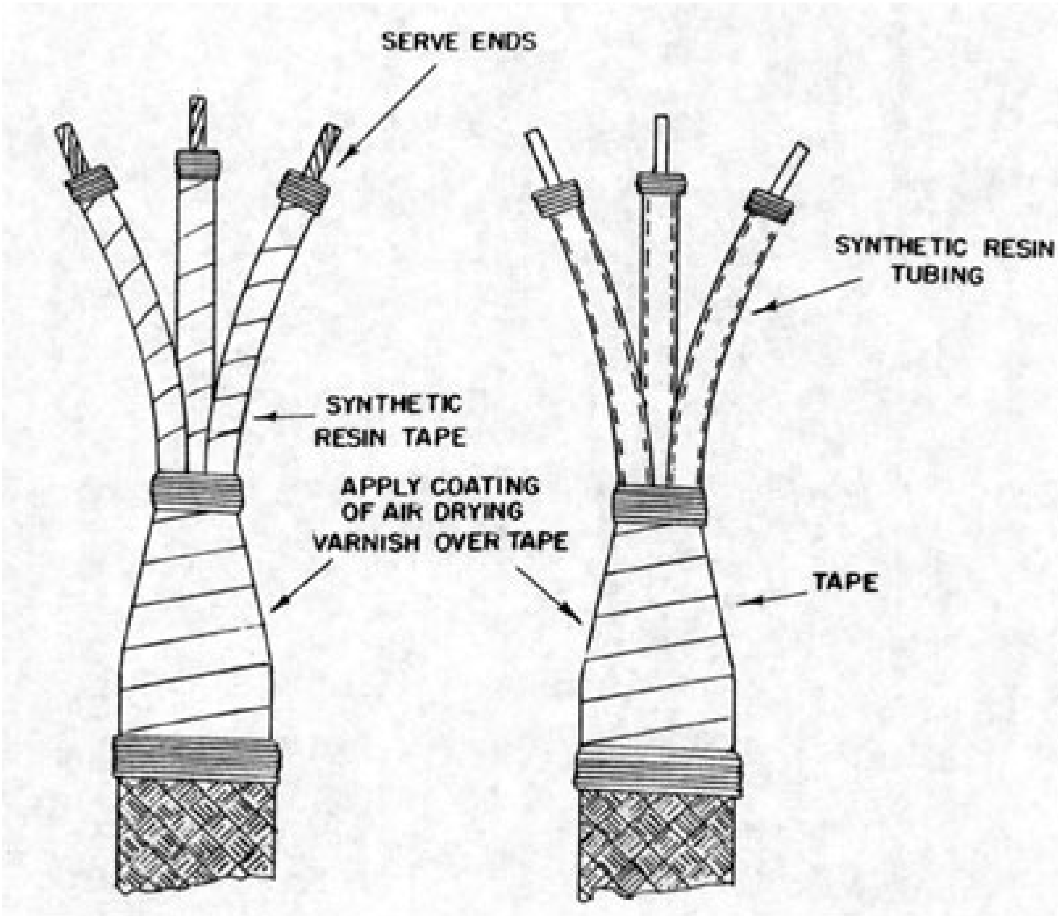


FIGURE 9-25
METHODS OF MAKING UP CABLE ENDS
OPEN EQUIPMENT

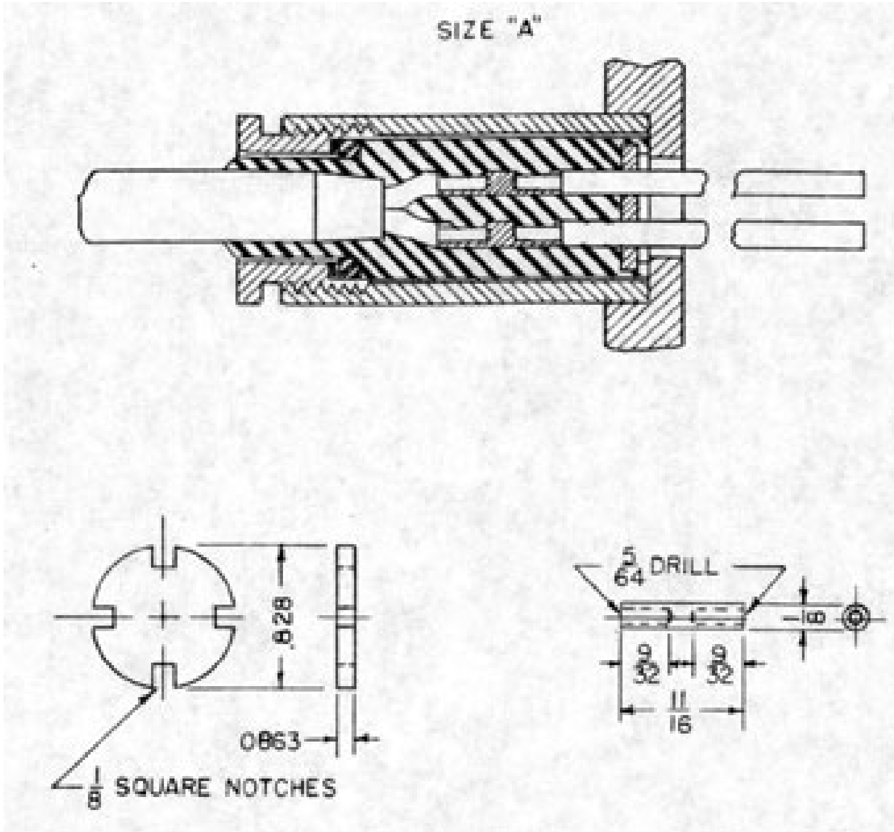


FIGURE 9-26
TYPICAL ASSEMBLY OF
MOLDED PACKING IN TUBE

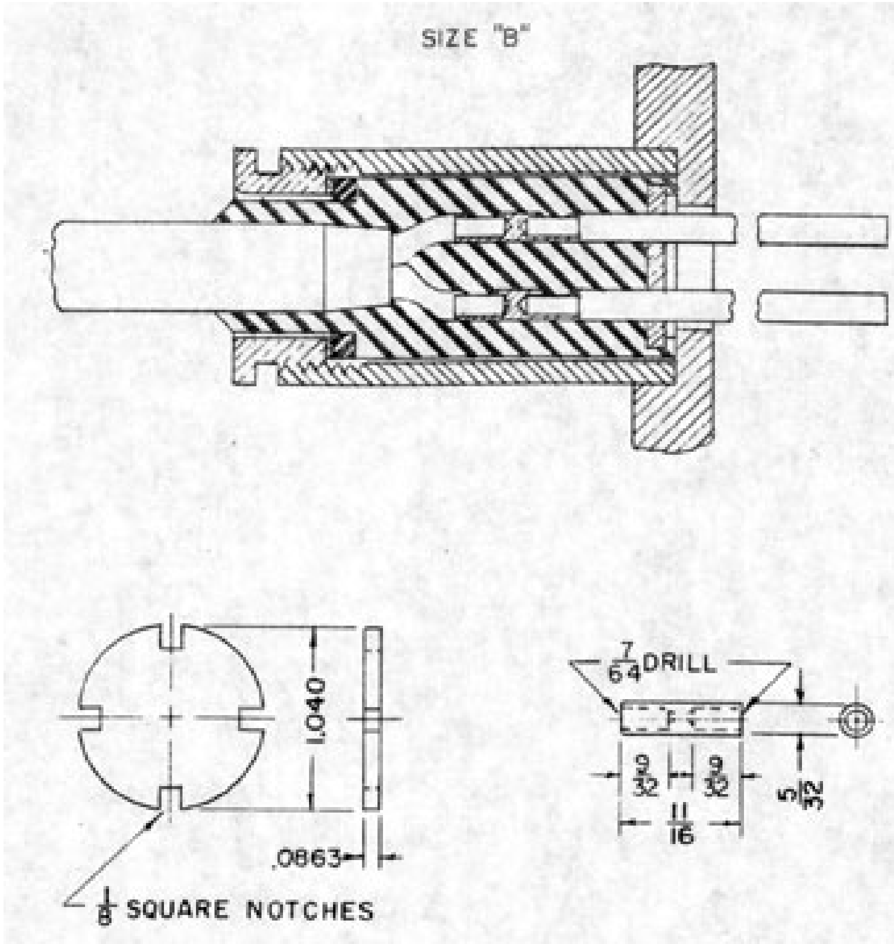


FIGURE 9-27
TYPICAL ASSEMBLY OF
MOLDED PACKING IN TUBE

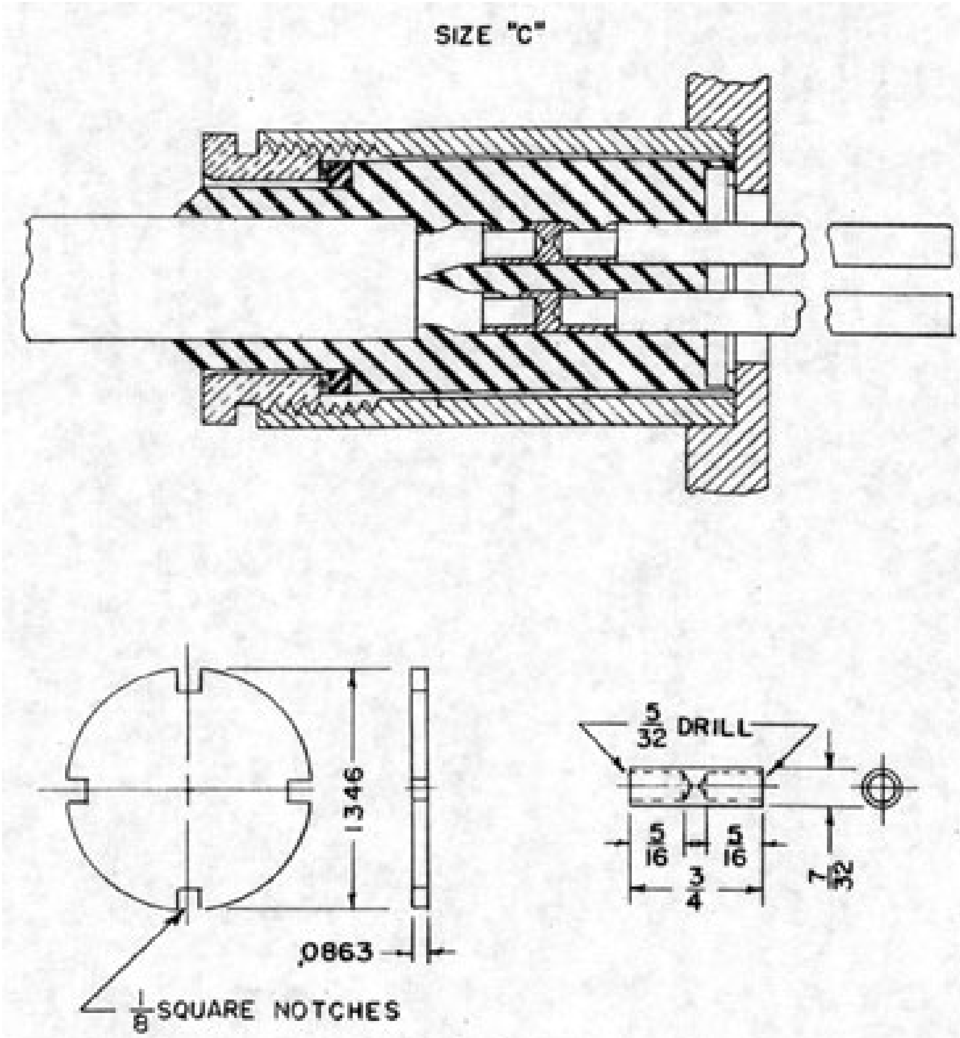


FIGURE 9-28
TYPICAL ASSEMBLY OF
MOLDED PACKING IN TUBE

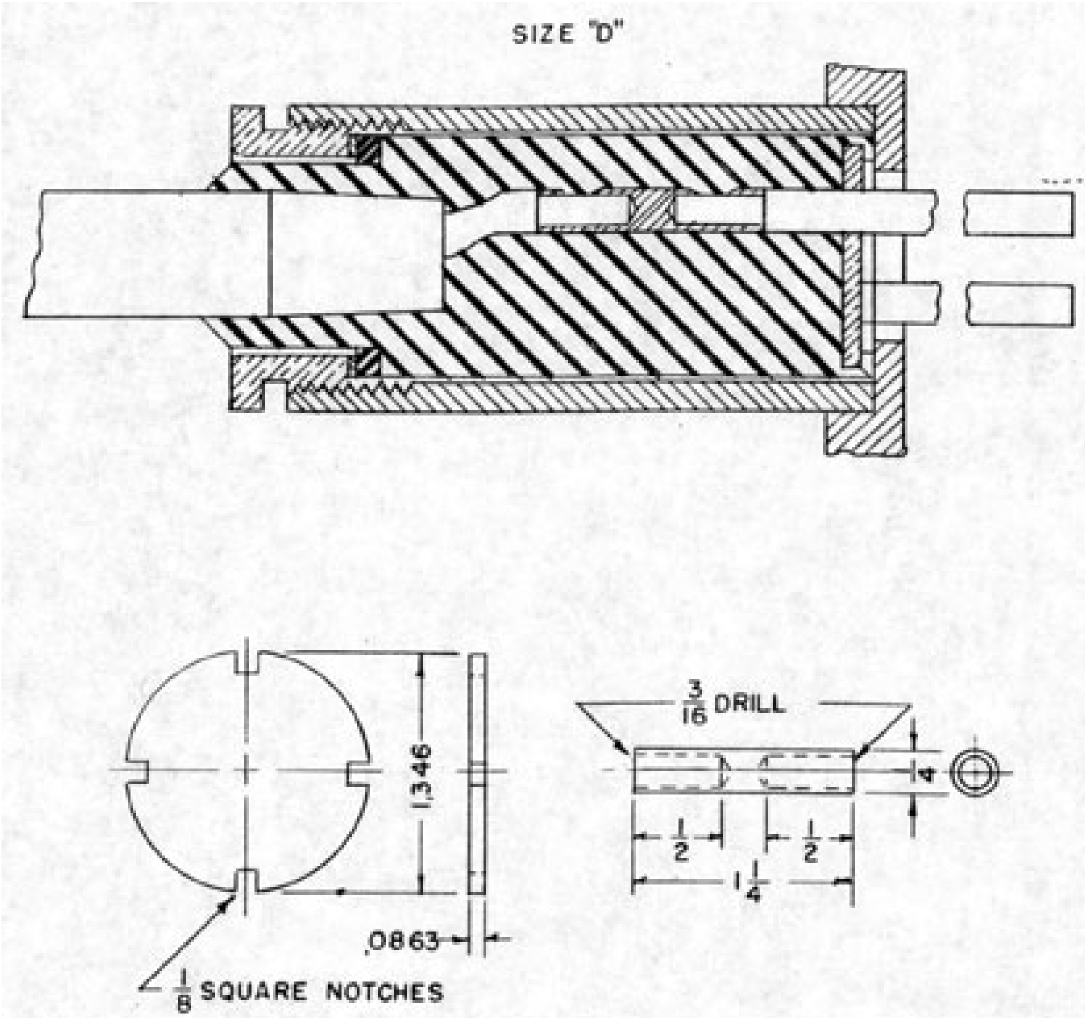


FIGURE 9-29
TYPICAL ASSEMBLY OF
MOLDED PACKING IN TUBE

**9-65**

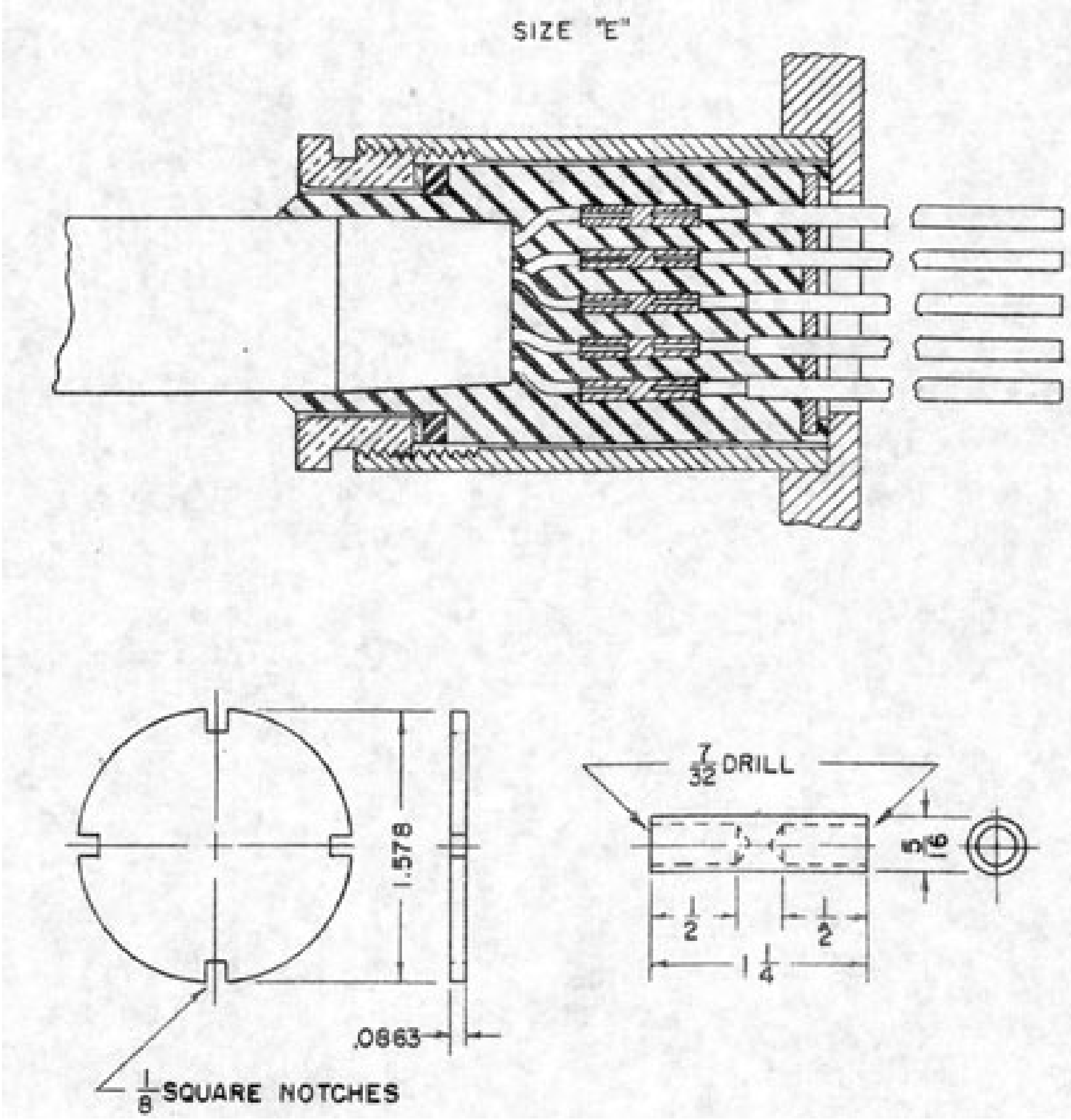


FIGURE 9-30
TYPICAL ASSEMBLY OF
MOLDED PACKING IN TUBE

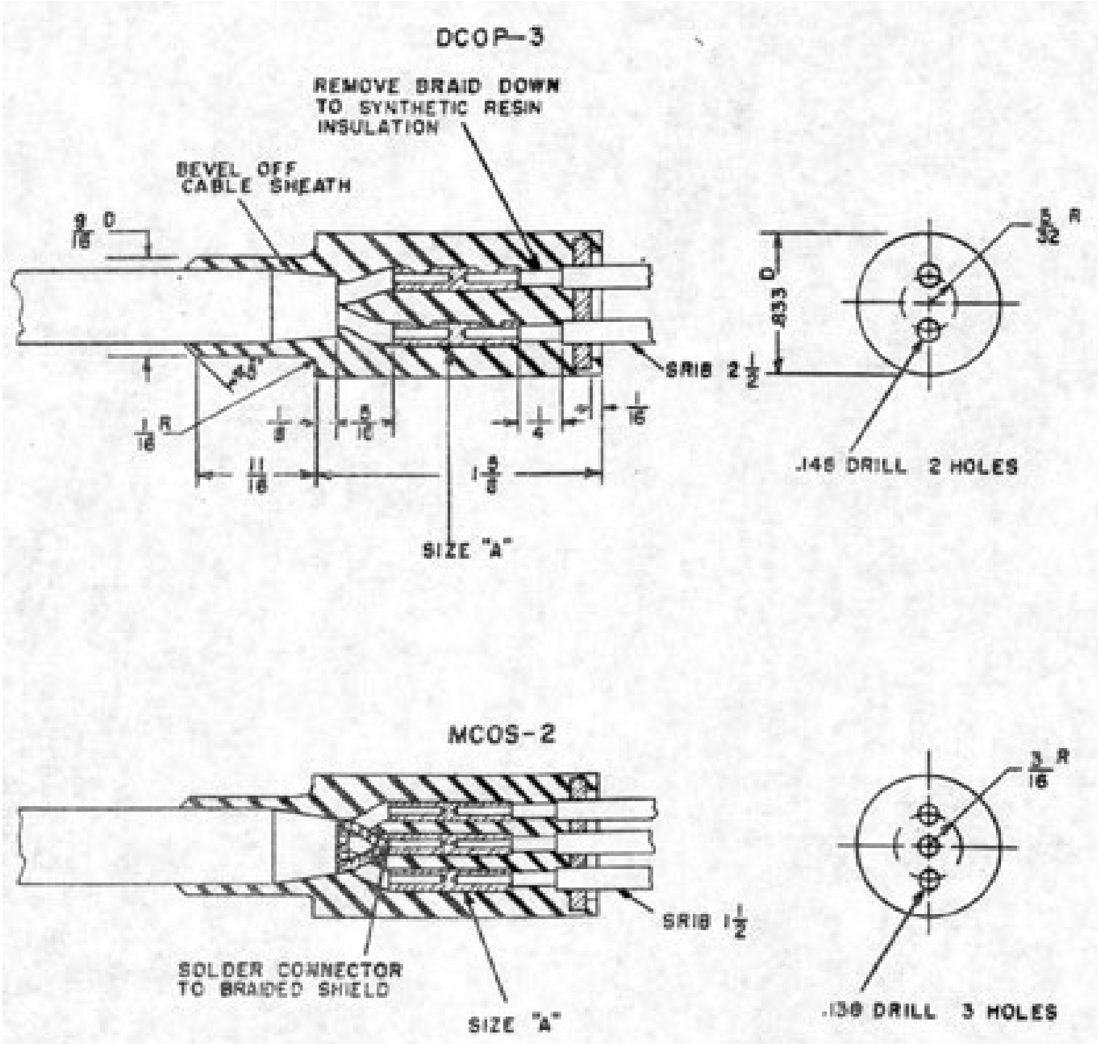


FIGURE 9-31
ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE A

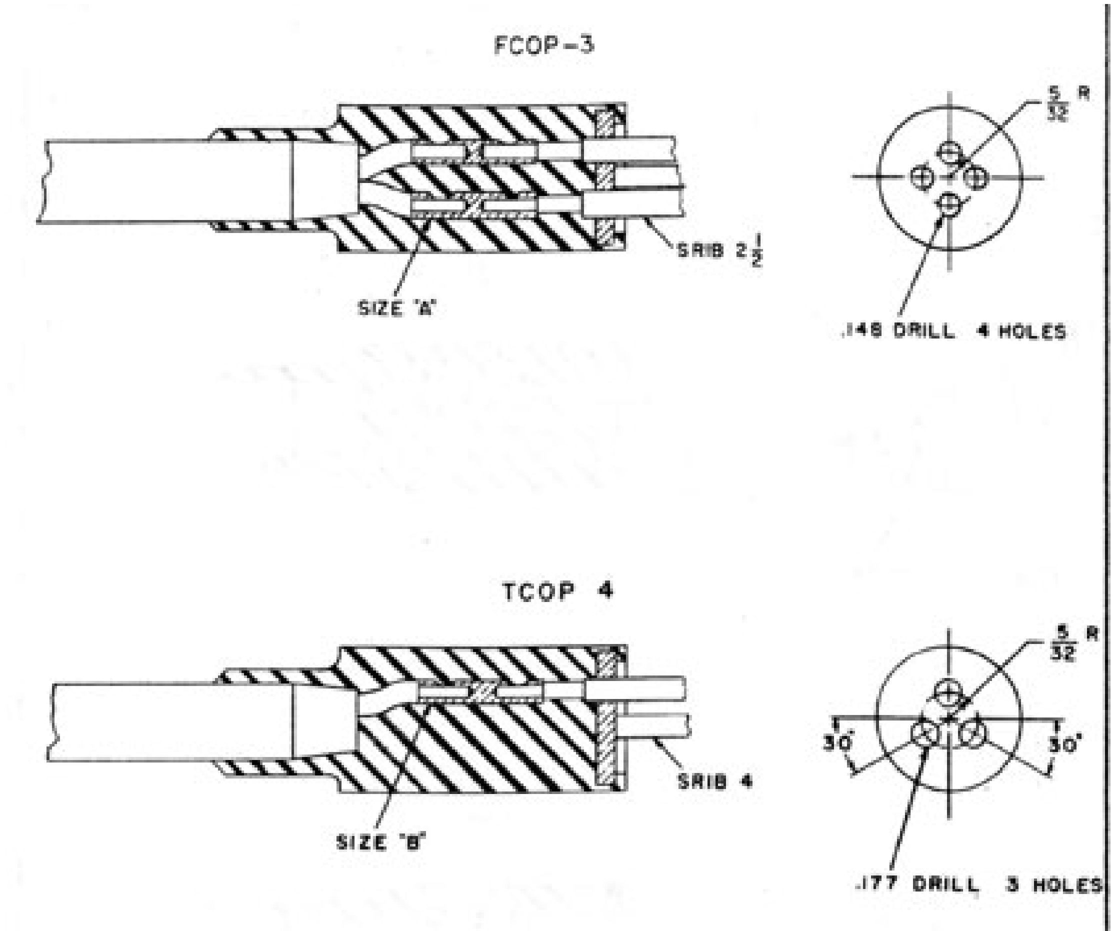


FIGURE 9-32
ARRANGEMENTS FOR SEALING CABLE ENDS IN
MOLDED PACKING SIZE A

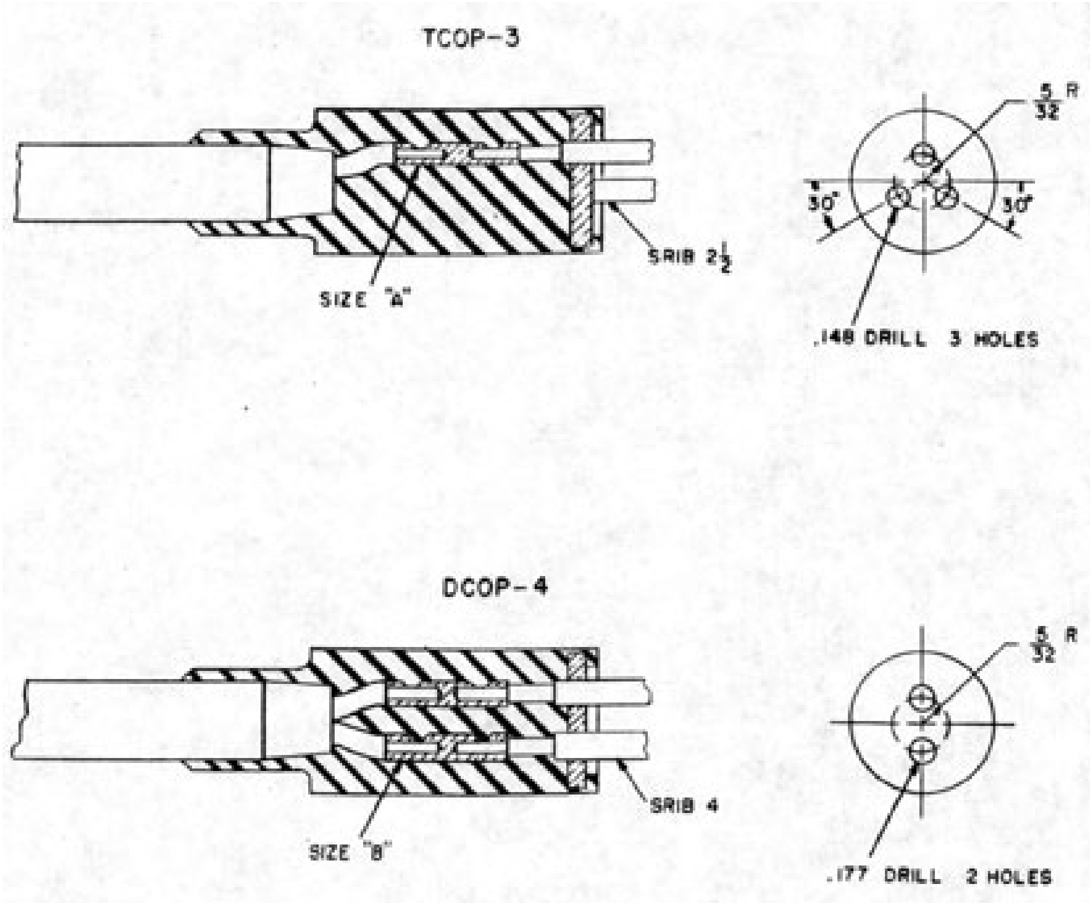


FIGURE 9-33 ARRANGEMENTS FOR SEALING CABLE ENDS IN MOLDED PACKING SIZE A

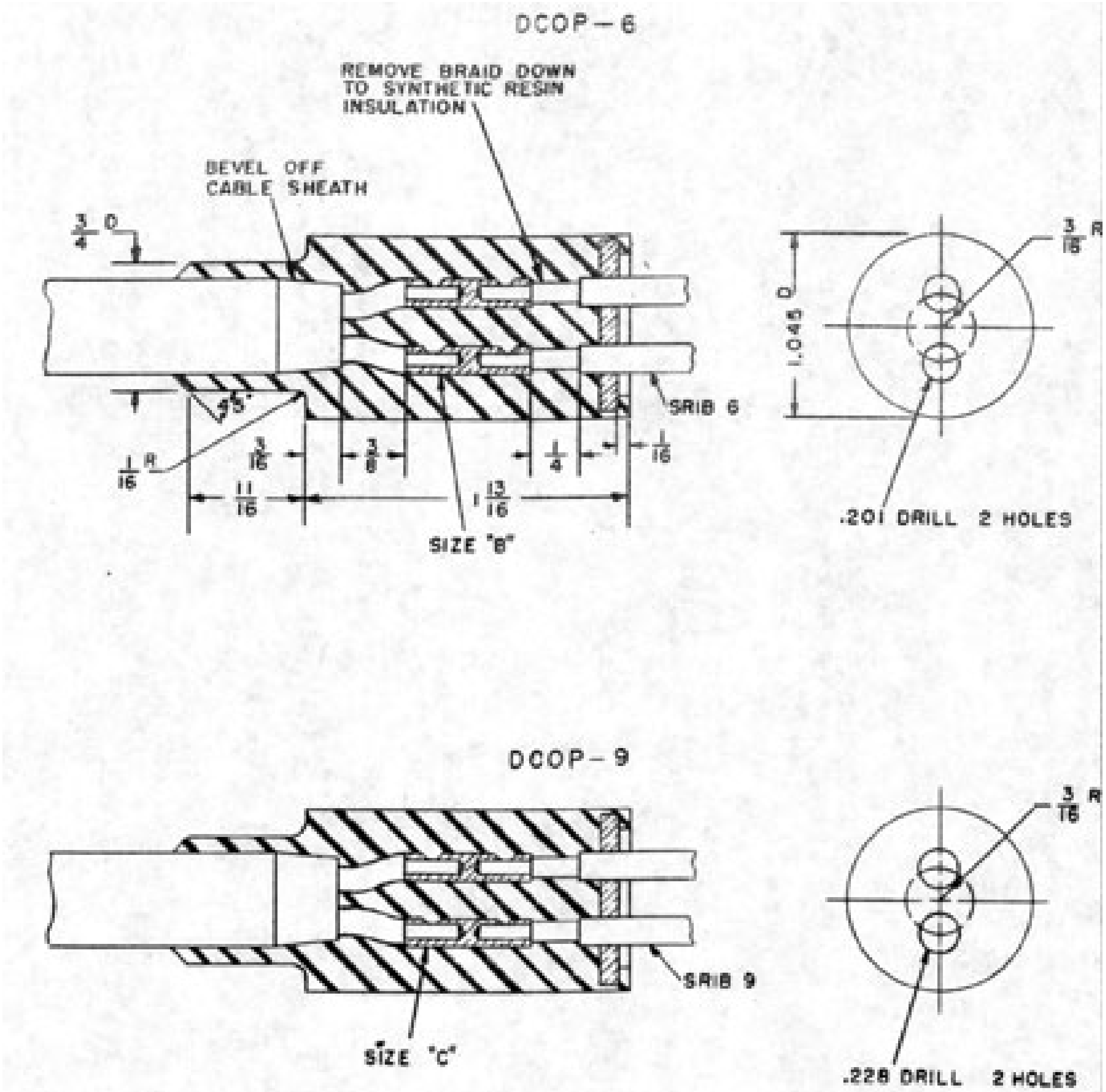


FIGURE 9-34
ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE B

**9-70**

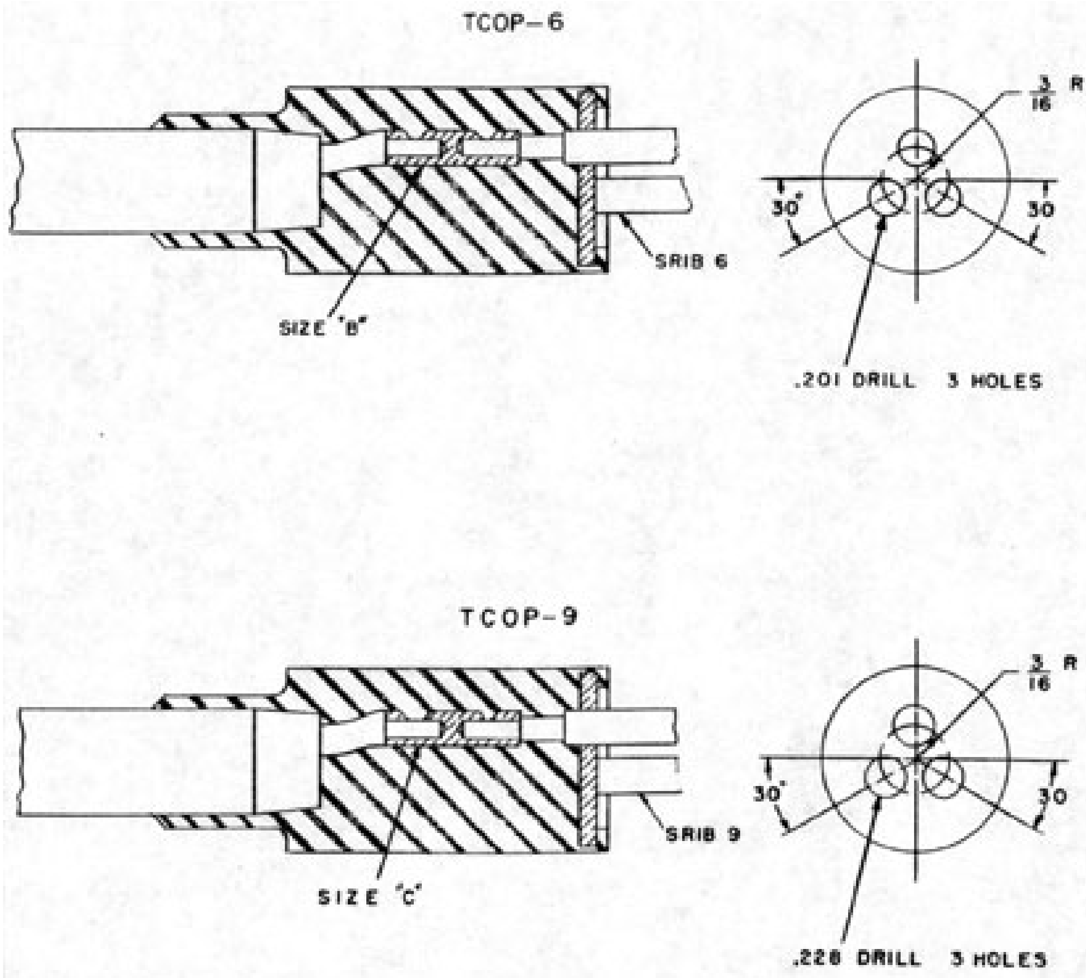


FIGURE 9-35
ARRANGEMENTS FOR SEALING CABLE ENDS IN
MOLDED PACKING SIZE B

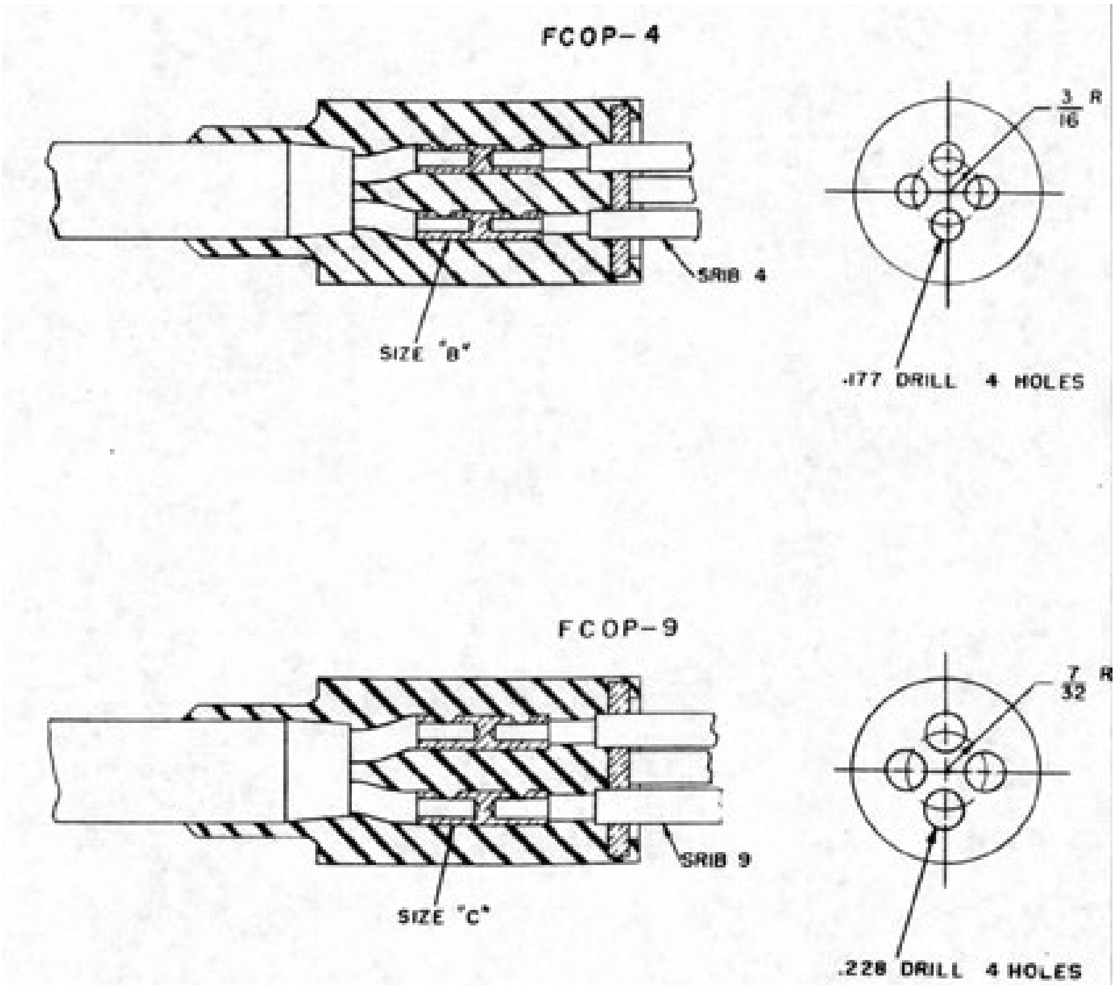


FIGURE 9-36
ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE B

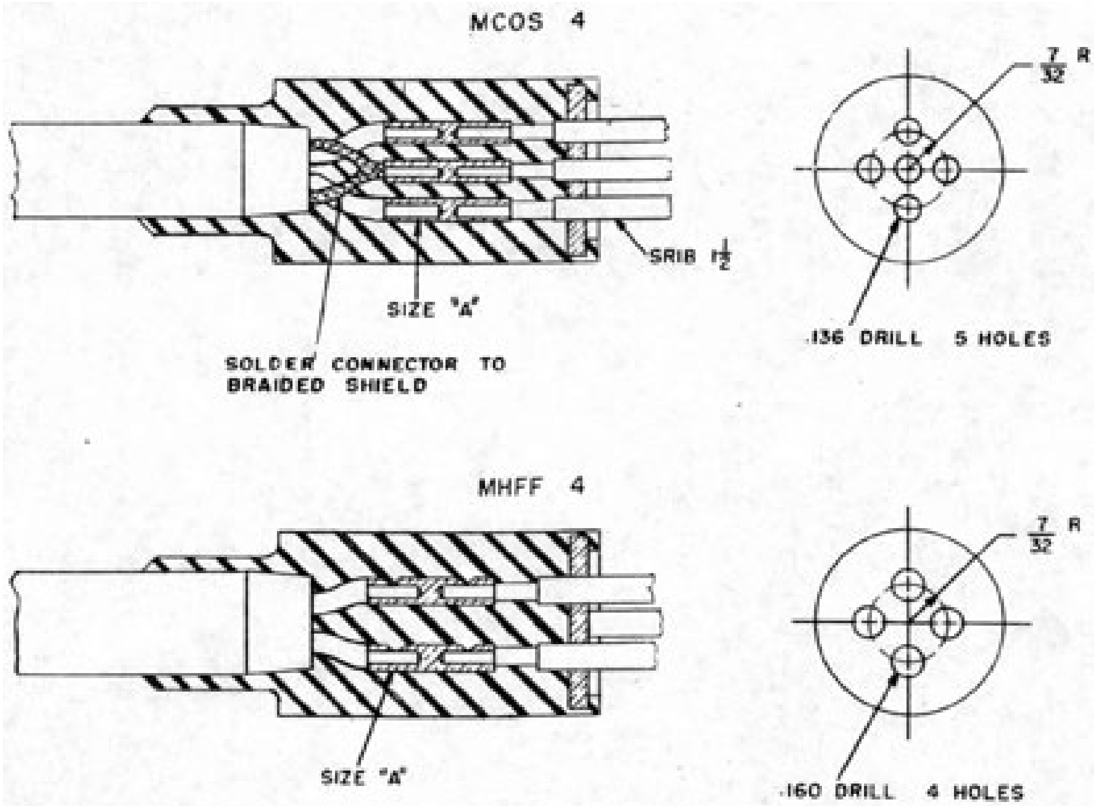


FIGURE 9-37
ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE B

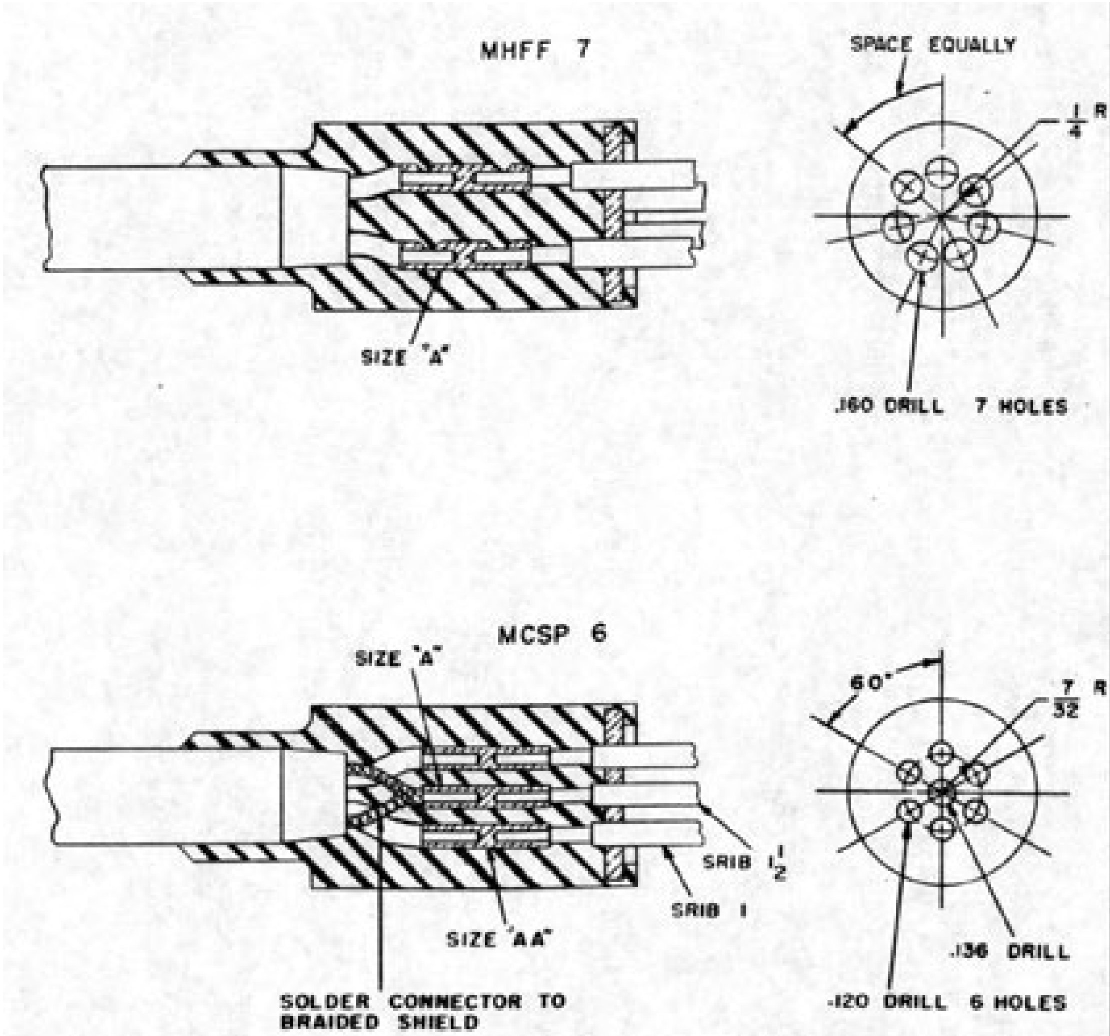


FIGURE 9-38
ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE B

**9-74**

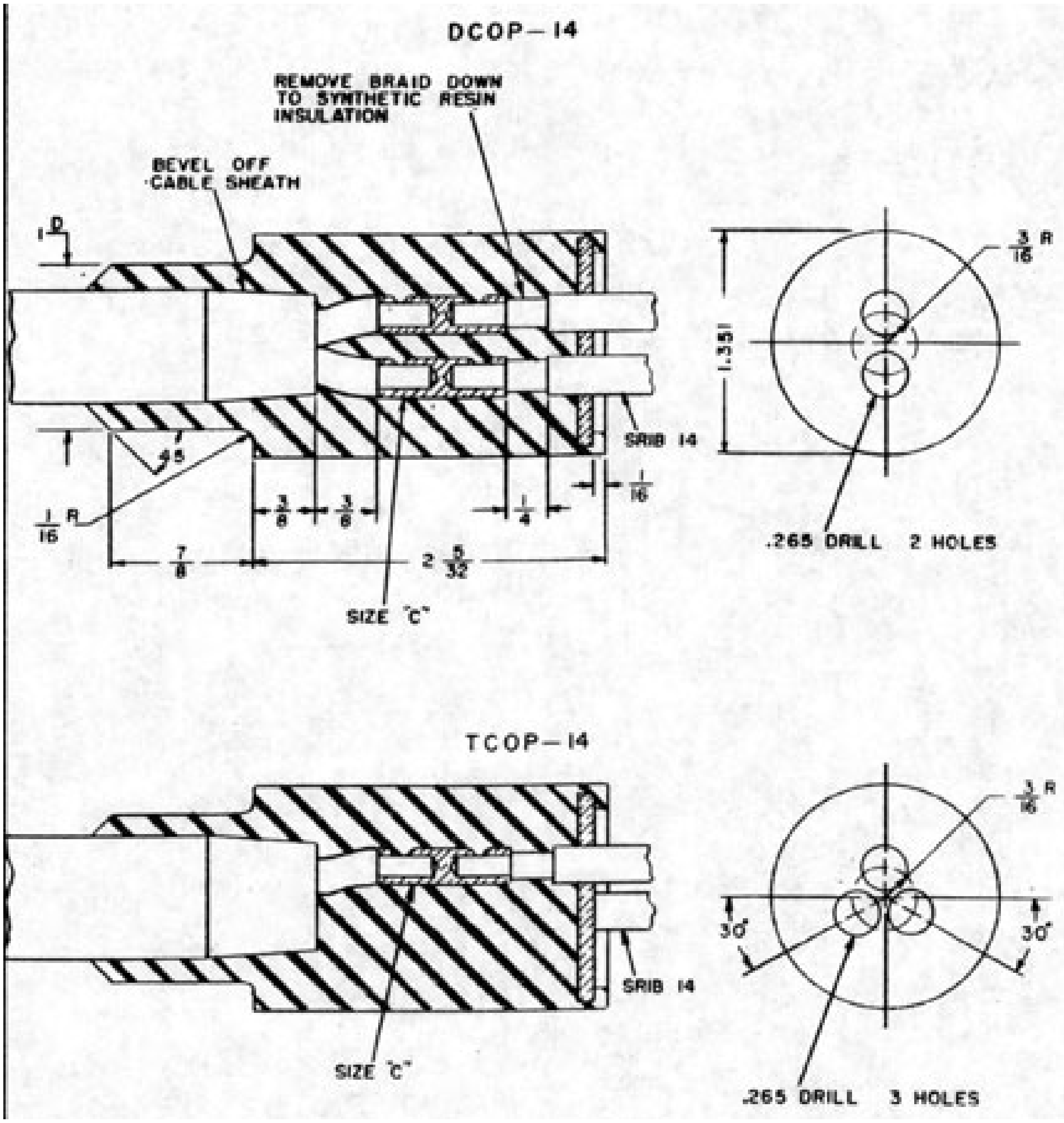


FIGURE 9-39
ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE C

**9-75**

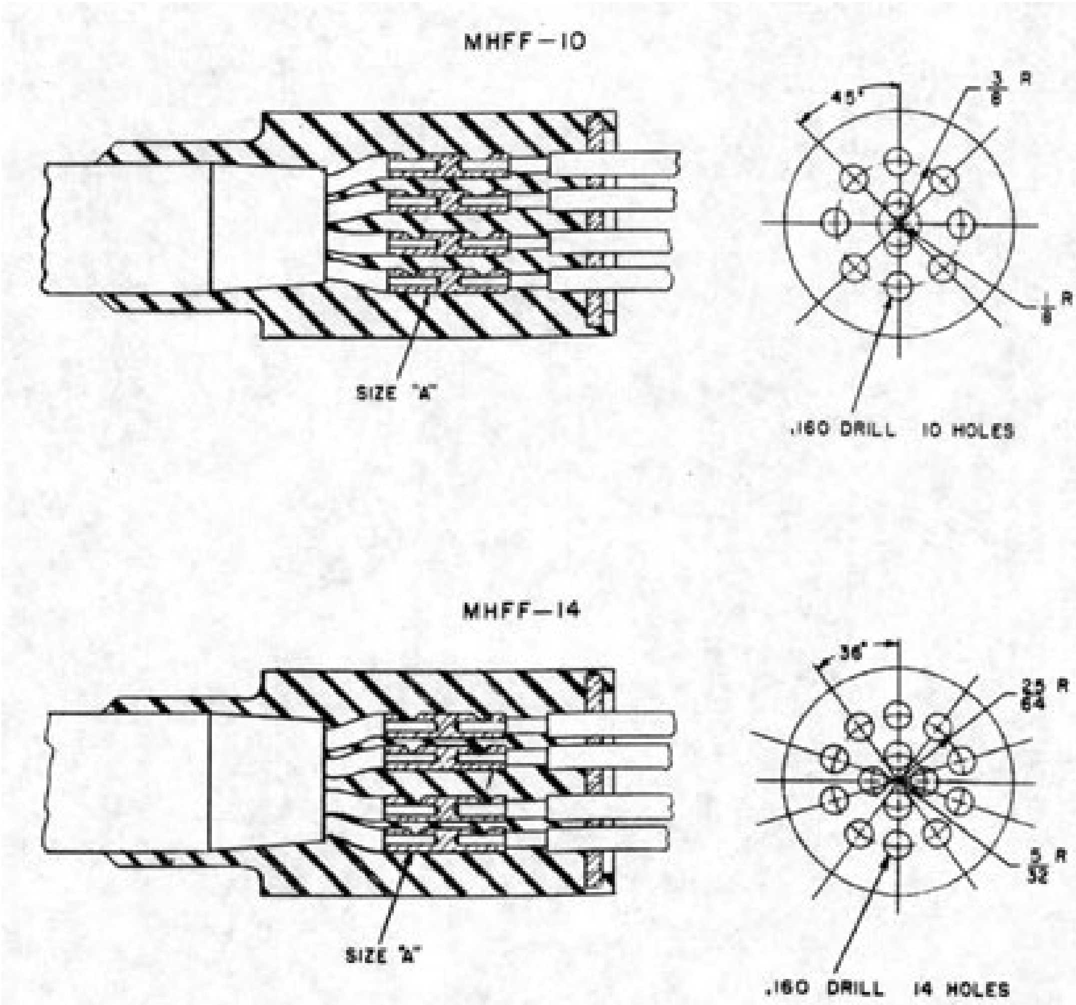


FIGURE 9-40
ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE C

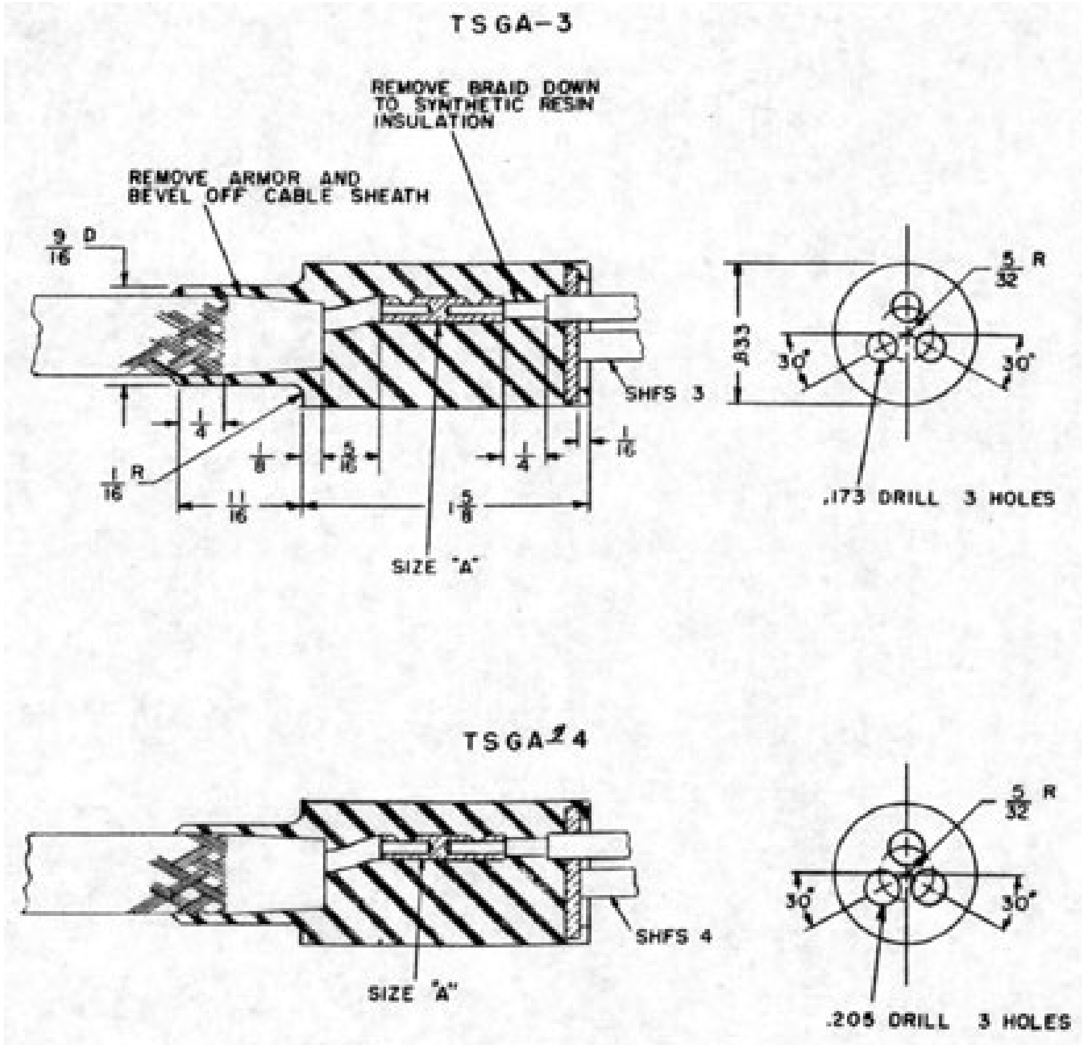


FIGURE 9-41
ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE A

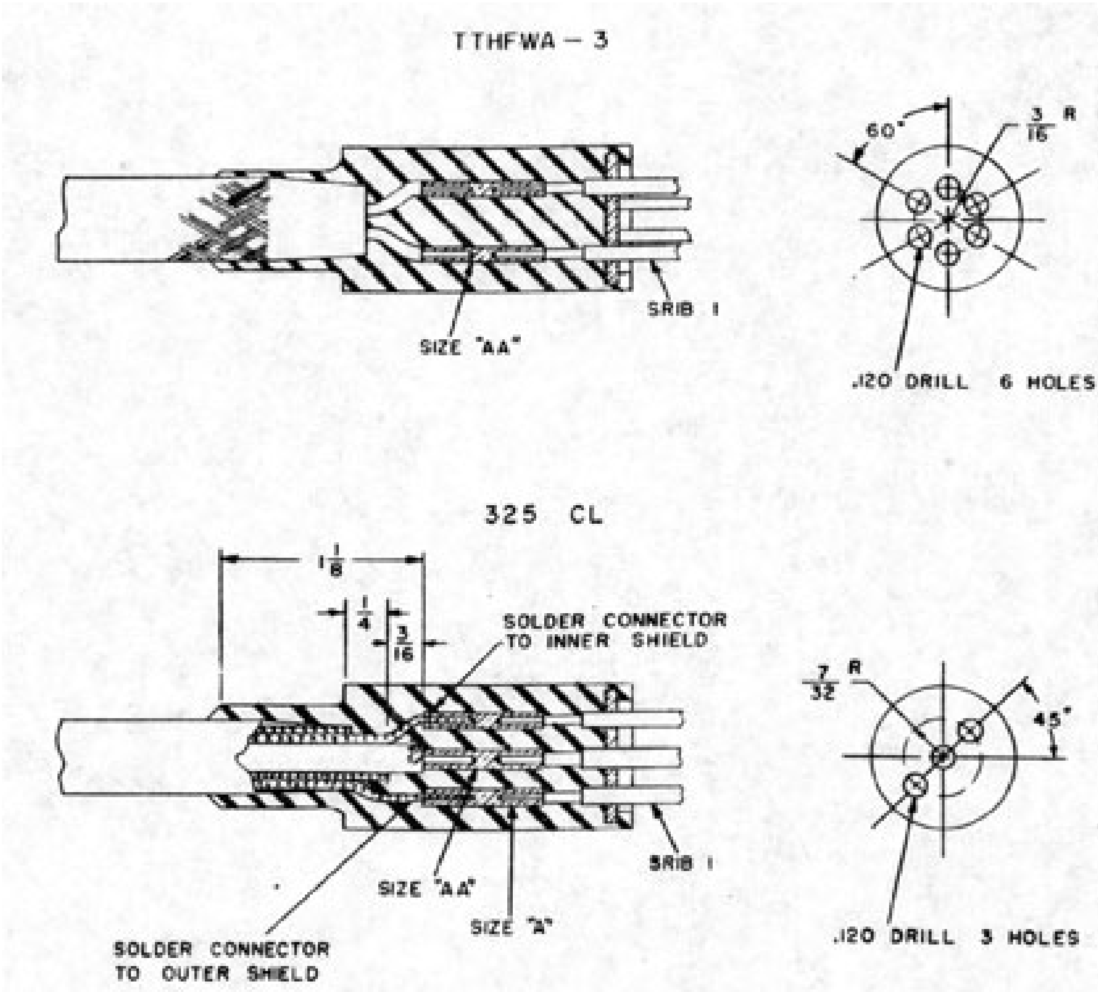


FIGURE 9-42
ARRANGEMENTS FOR SEALING CABLE ENDS IN
MOLDED PACKING SIZE A



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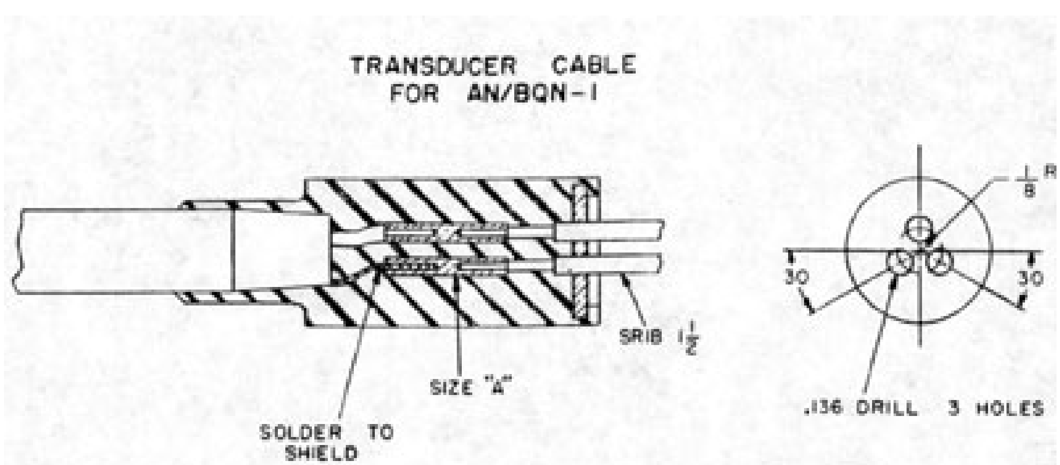


FIGURE 9-43

ARRANGEMENT FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE A

**9-79**

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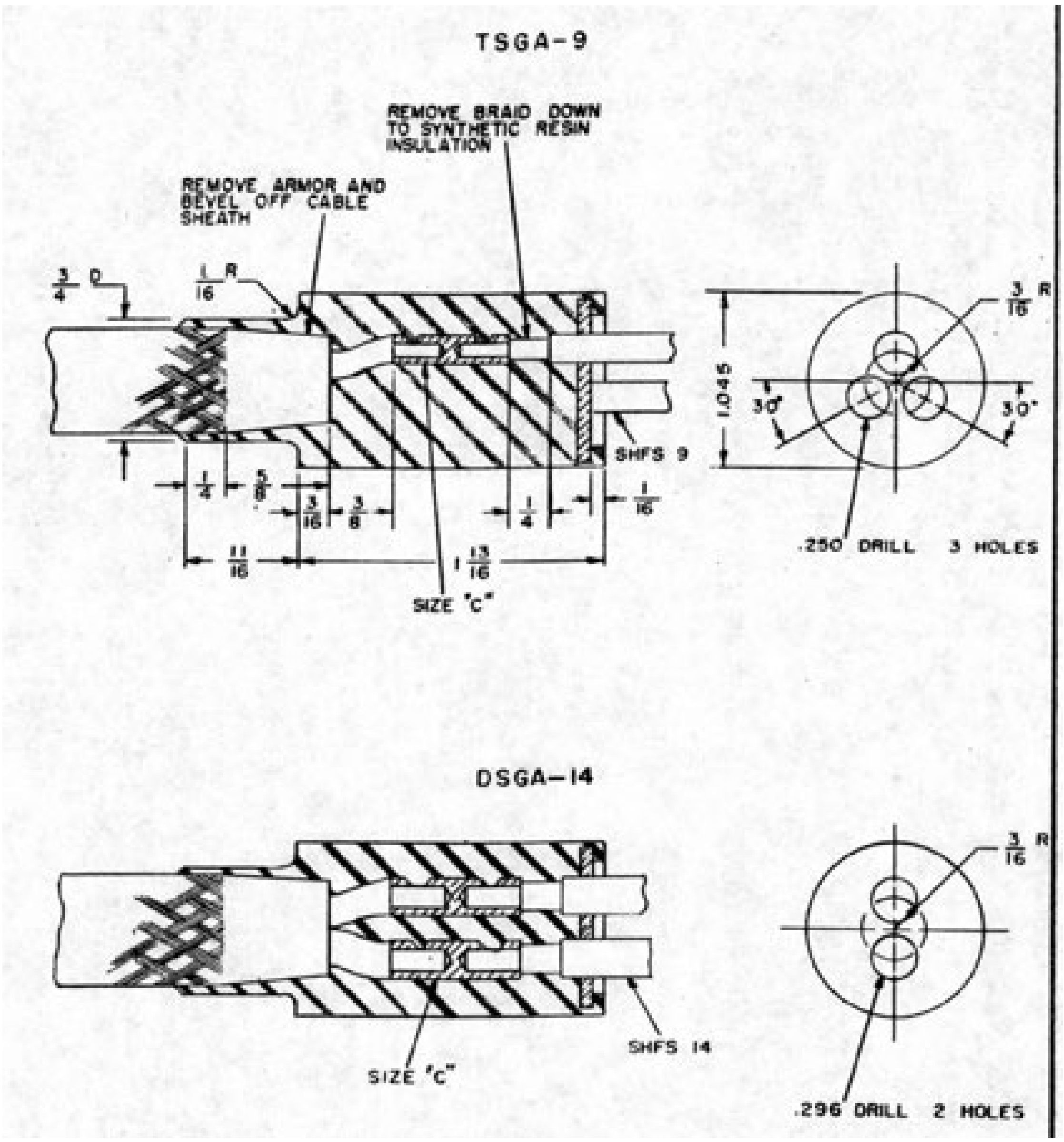


FIGURE 9-44
ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE B

**9-80**

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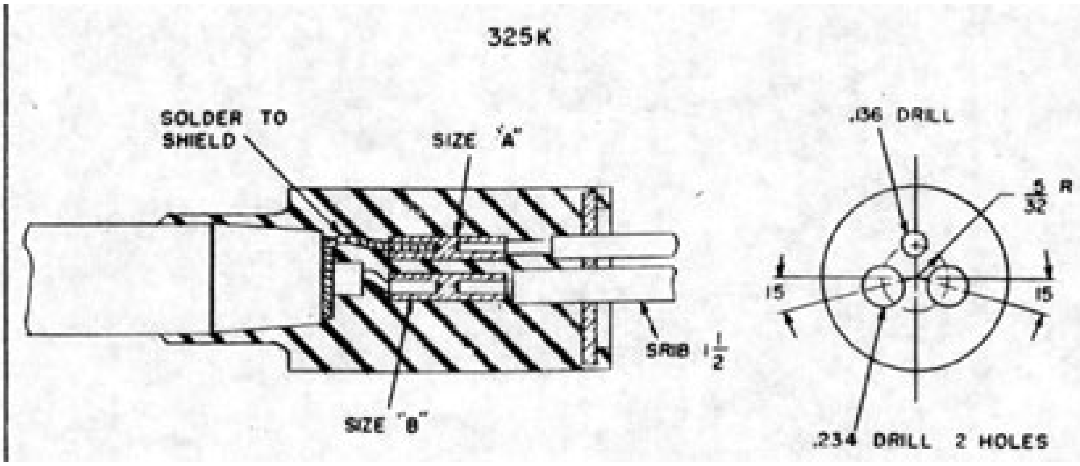



FIGURE 9-45
ARRANGEMENT FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE B

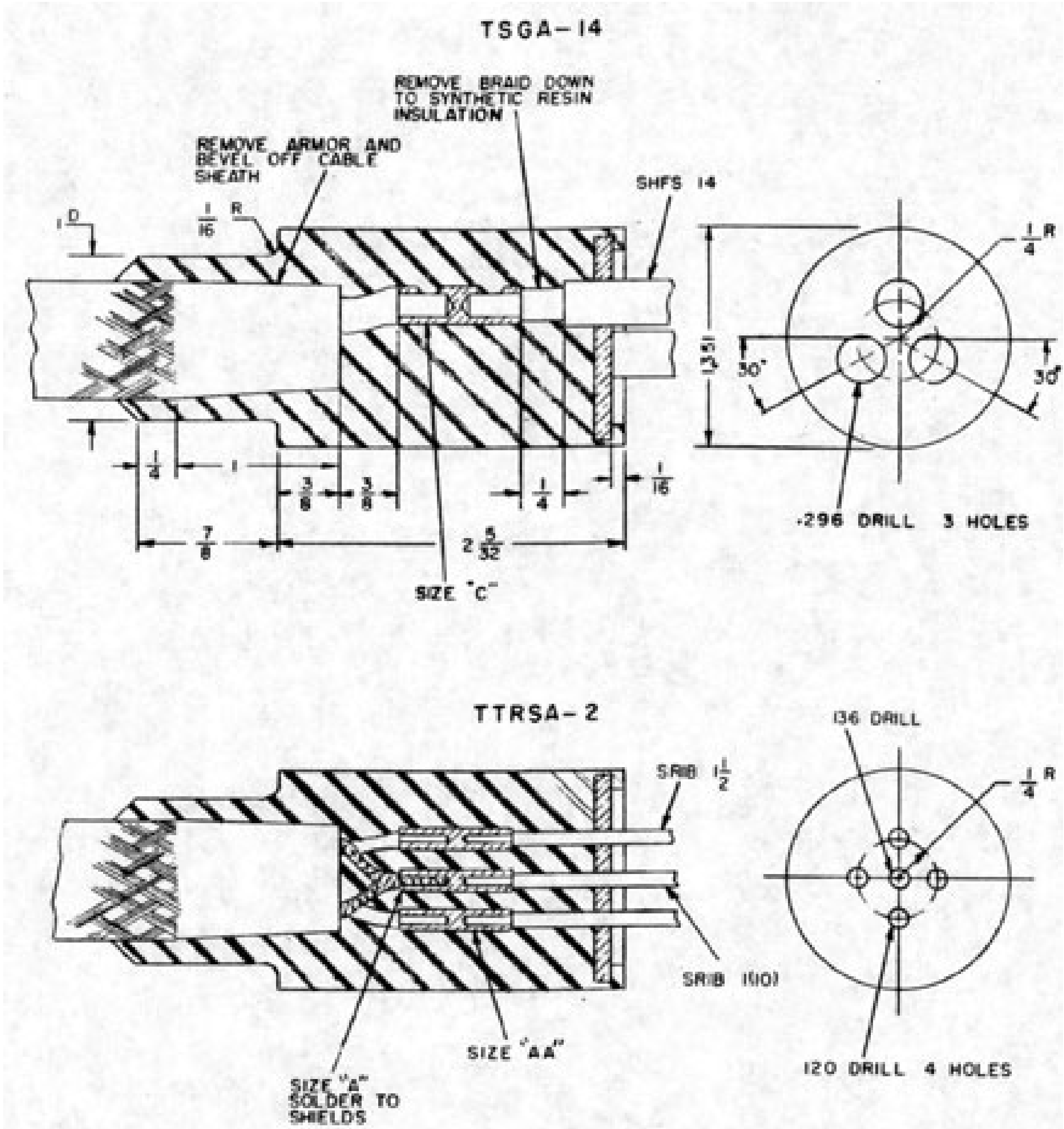



FIGURE 9-46
ARRANGEMENTS FOR SEALING CABLE ENDS IN
MOLDED PACKING SIZE C

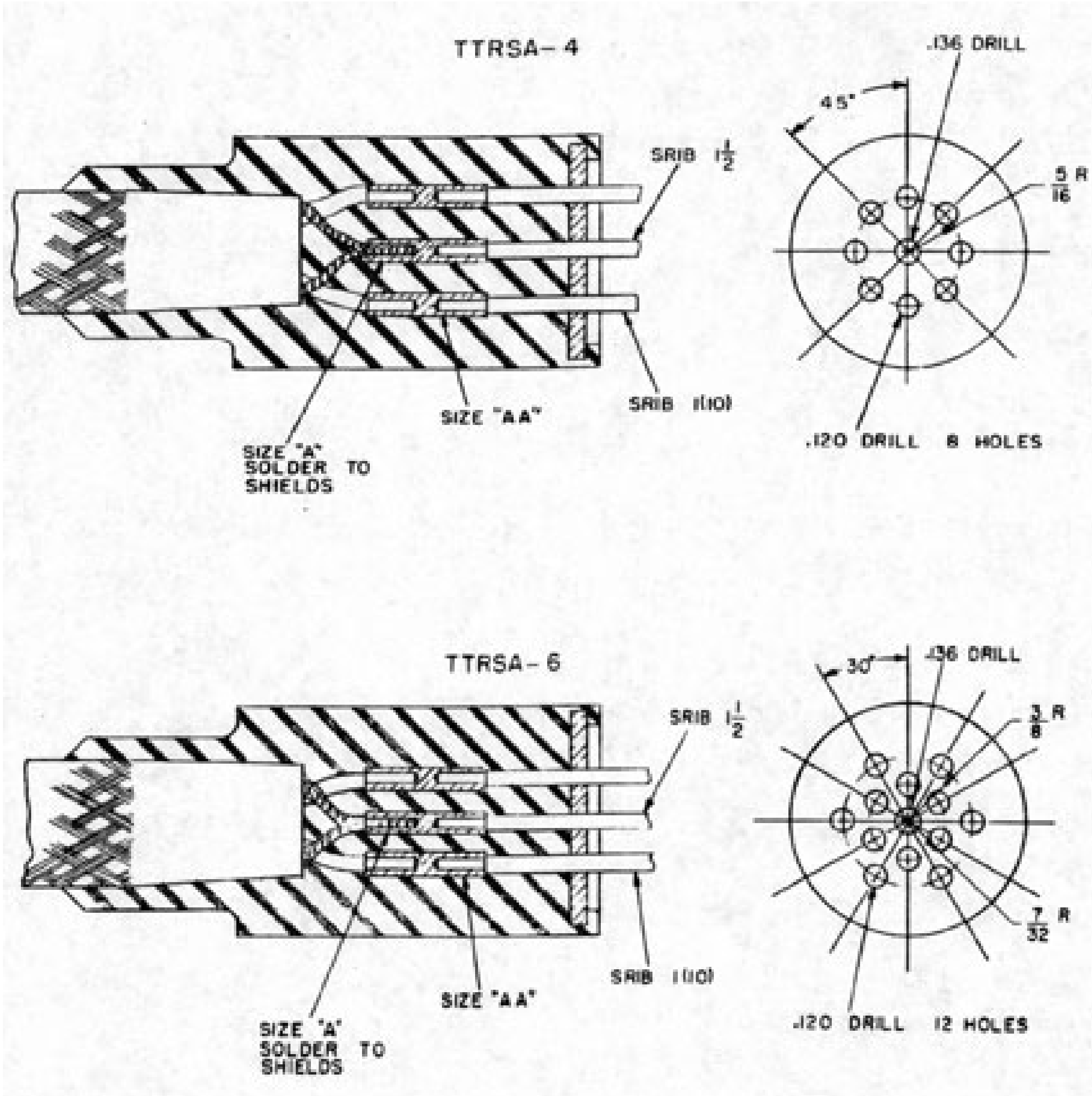



FIGURE 9-47
ARRANGEMENTS FOR SEALING CABLE ENDS IN
MOLDED PACKING SIZE C

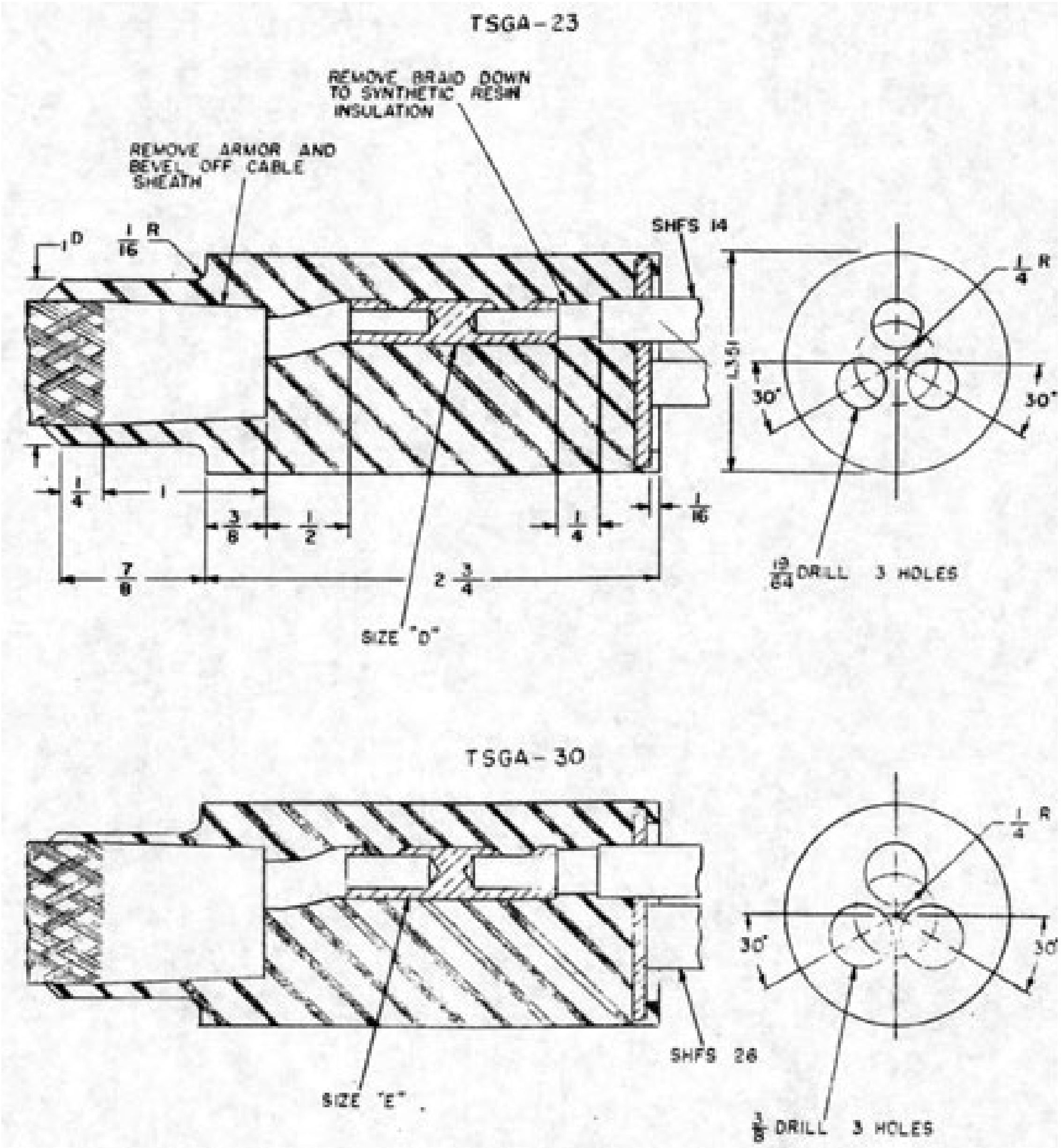



FIGURE 9-48
ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED RACKING SIZE D

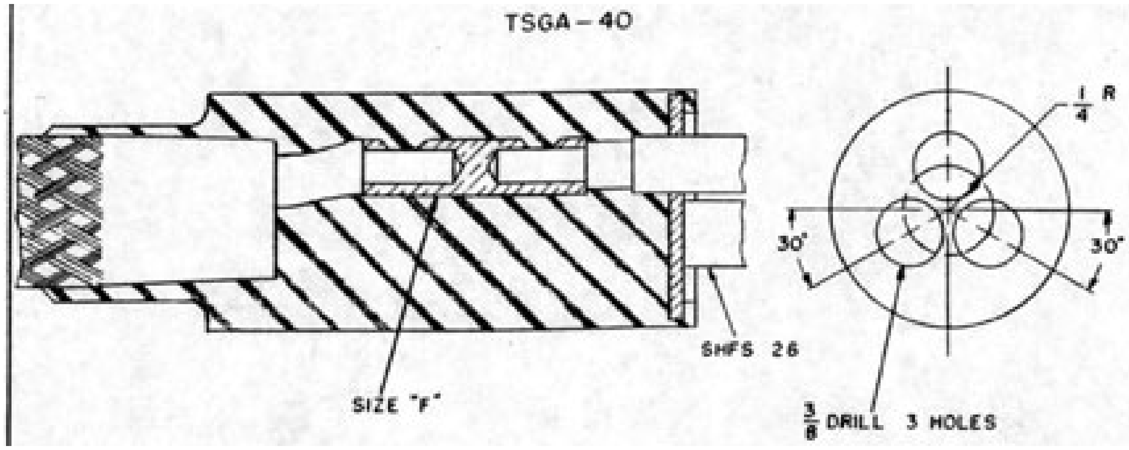



FIGURE 9-49
ARRANGEMENT FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE D

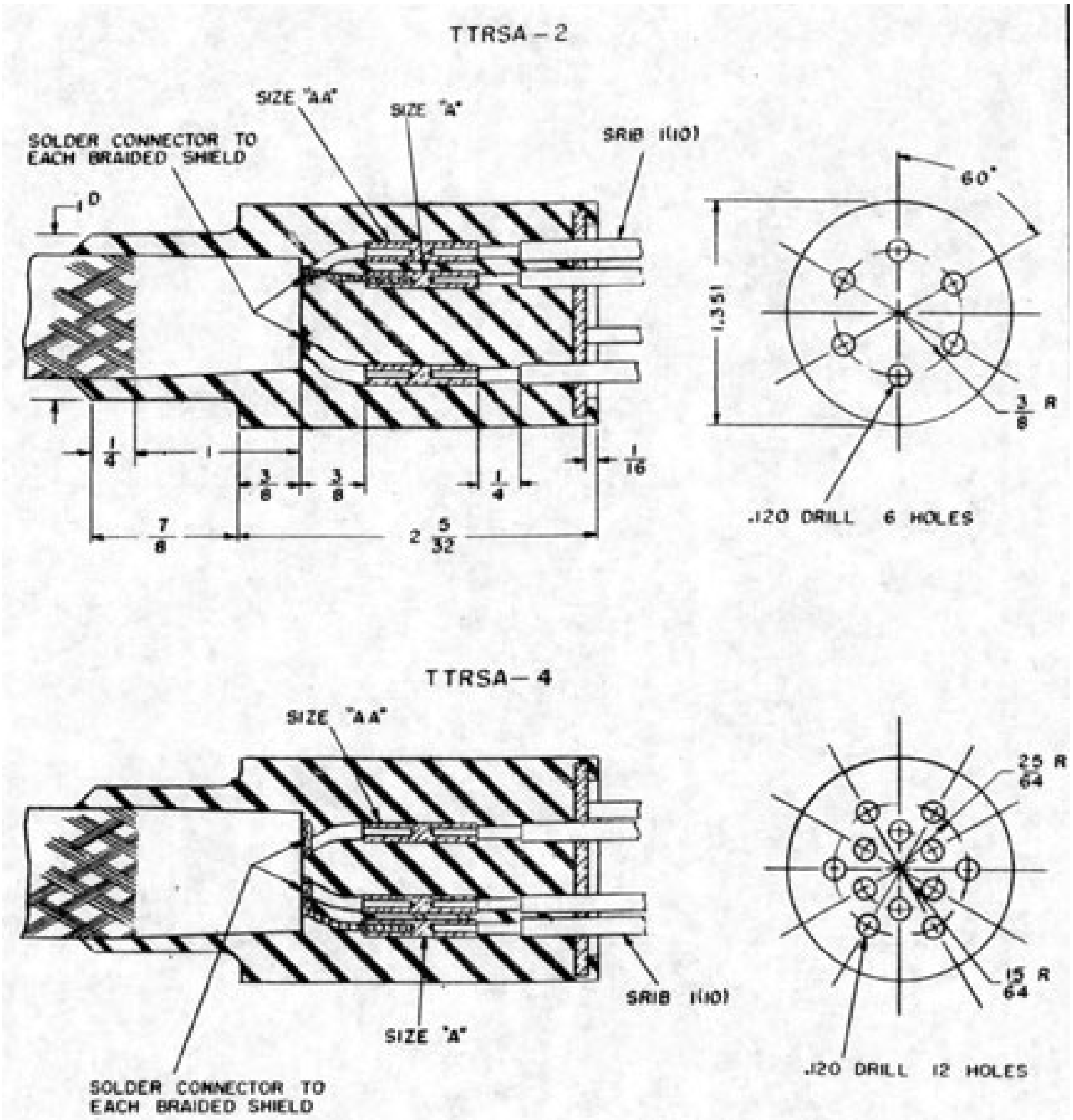



FIGURE 9-50
ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE C

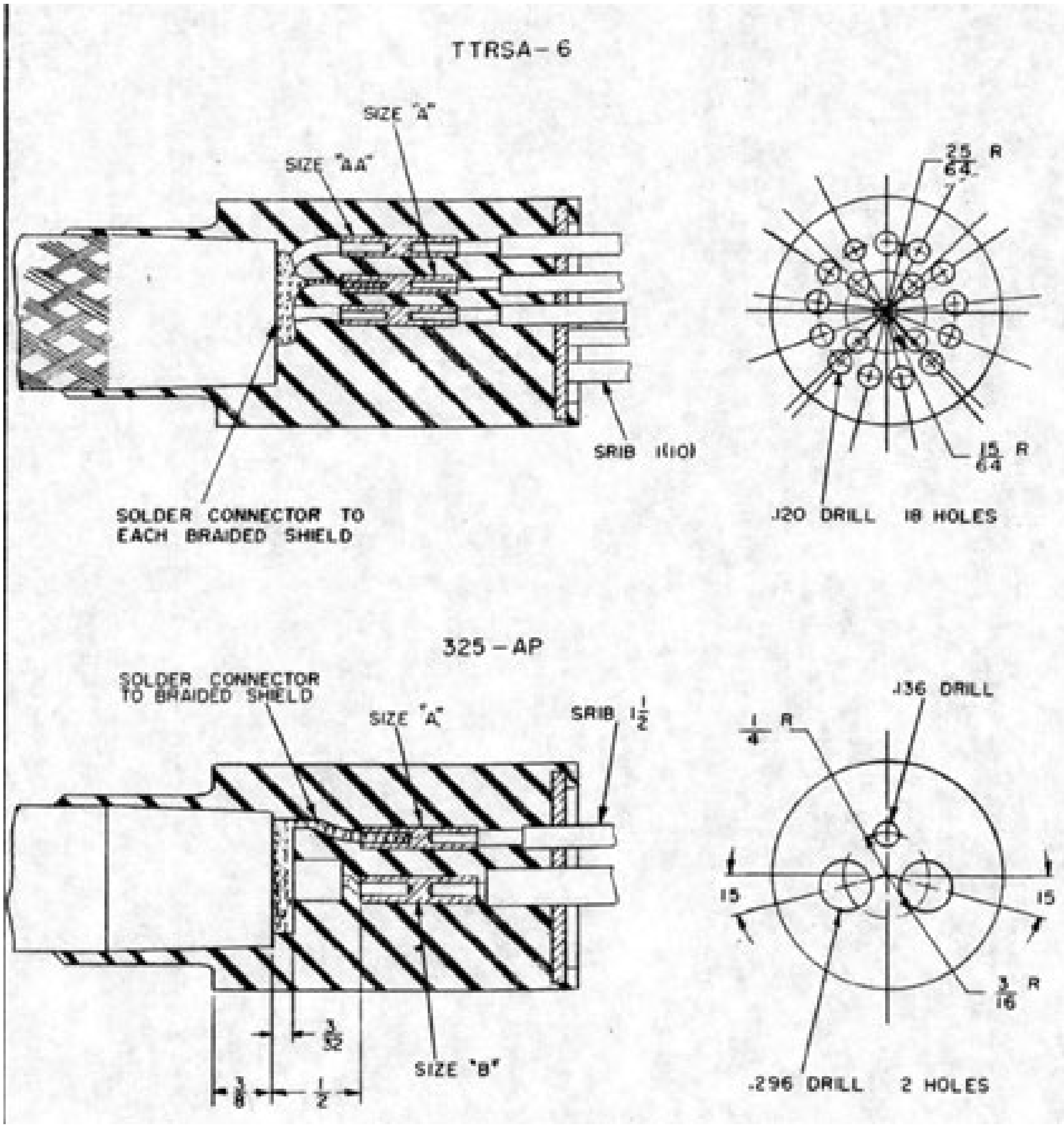



FIGURE 9-51
ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE C

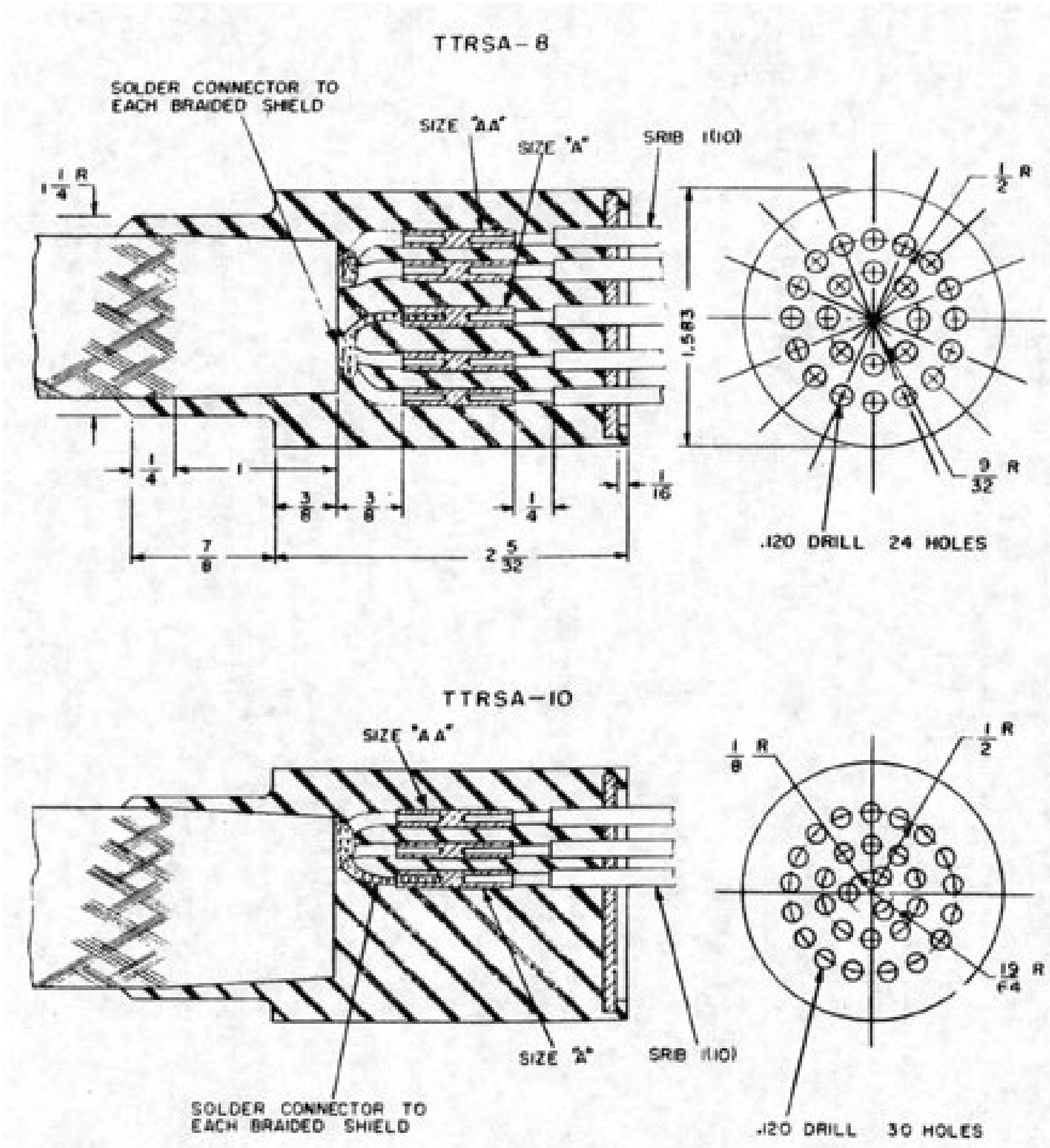



FIGURE 9-52
ARRANGEMENTS FOR SEALING CABLE ENDS IN
MOLDED PACKING SIZE E

**9-88**

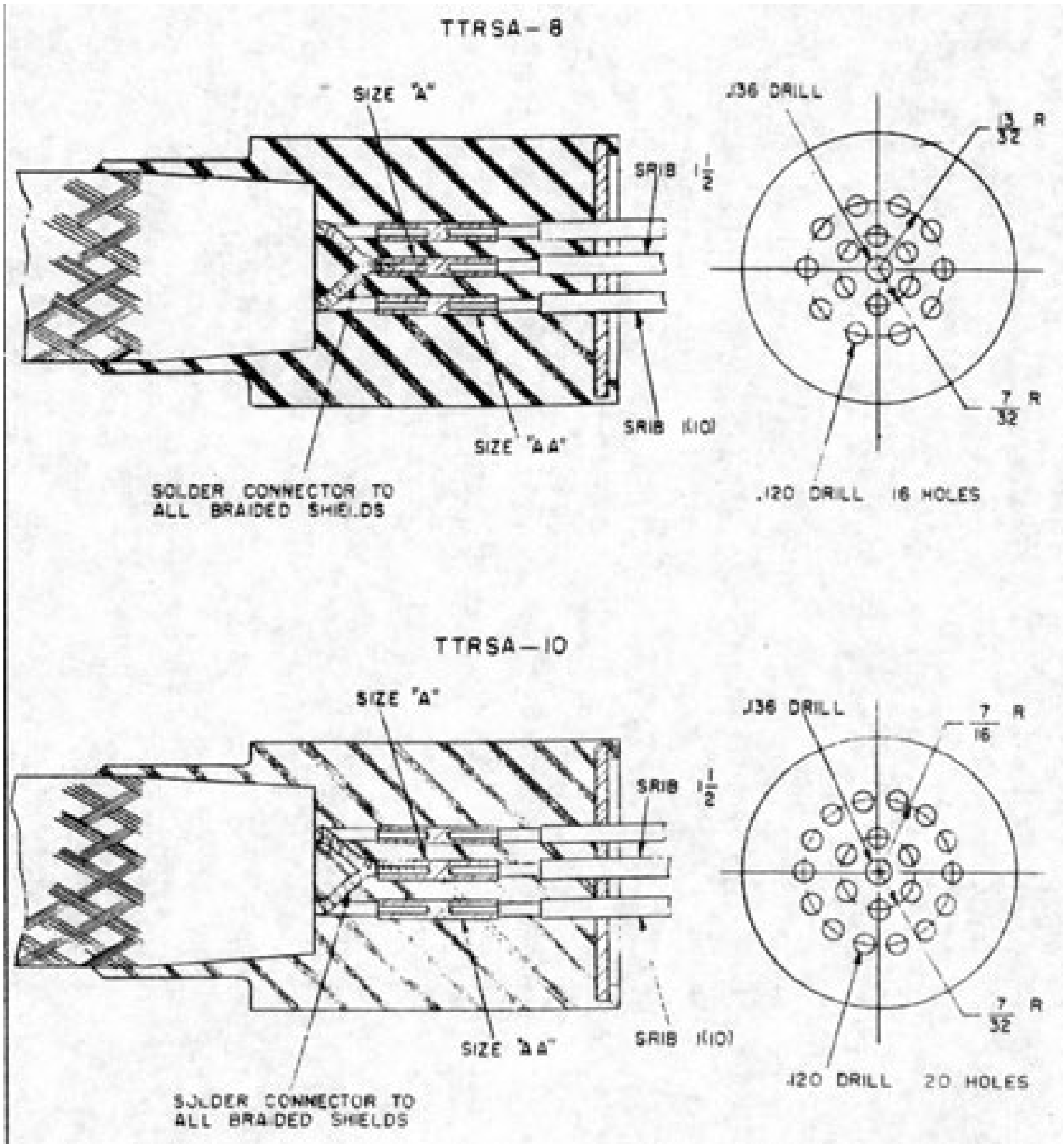



FIGURE 9-53 ARRANGEMENTS FOR SEALING
CABLE ENDS IN
MOLDED PACKING SIZE E

5. APPLYING TERMINAL LUGS.

When cutting back insulation to allow installation of lugs, remove just enough insulation so that the stripped conductor will fit the lug exactly. Take particular care not to cut any part of the conductor, since even a slight nick will weaken it and eventually cause the conductor to break. Hand wire strippers are very useful for removing insulation (See Chapter 3) or with a little experience, a sharp knife or diagonal cutter may be used efficiently.

Always use a lug large enough to fit over all strands of the conductor. In the event a lug must be used that is too small, and no alternative is offered, the following method is recommended:

Fan back the outer strands of the conductor, cut out the center strands, and form back the outer strands to fit the lug. **At the present time**, all lugs used on electronic installations must be soldered, with a few exceptions. Solder-less type lugs may be utilized to provide a good mechanical and electrical connection by crimping and soldering both.

The new reduced diameter cables have a waterproofing compound (silicone grease) which fills all voids even in individual conductors. This grease makes the soldering of terminal lugs very difficult. Individual strands must be cleaned with "Decalene" (Deca-HydroNapthalene). To speed up installation work involving these cables, a solder-less terminal connector has been approved on a few installations. The connector, method of crimp, and tooling are taken up in Chapter 5. The crimp is known as the confined "C" crimp with insulation support and is manufactured by Aircraft Marine Products, Inc. The crimping tool, Figure 9-54 is equipped with a ratchet to insure a uniform crimp. The ratchet will not release until the crimping cycle is completed. The tool performs a double action; it crimps the terminal barrel to the conductors and the insulation grip to the insulation sheath. Always use the recommended tool to crimp solderless terminals. **Never** use diagonals for crimping.

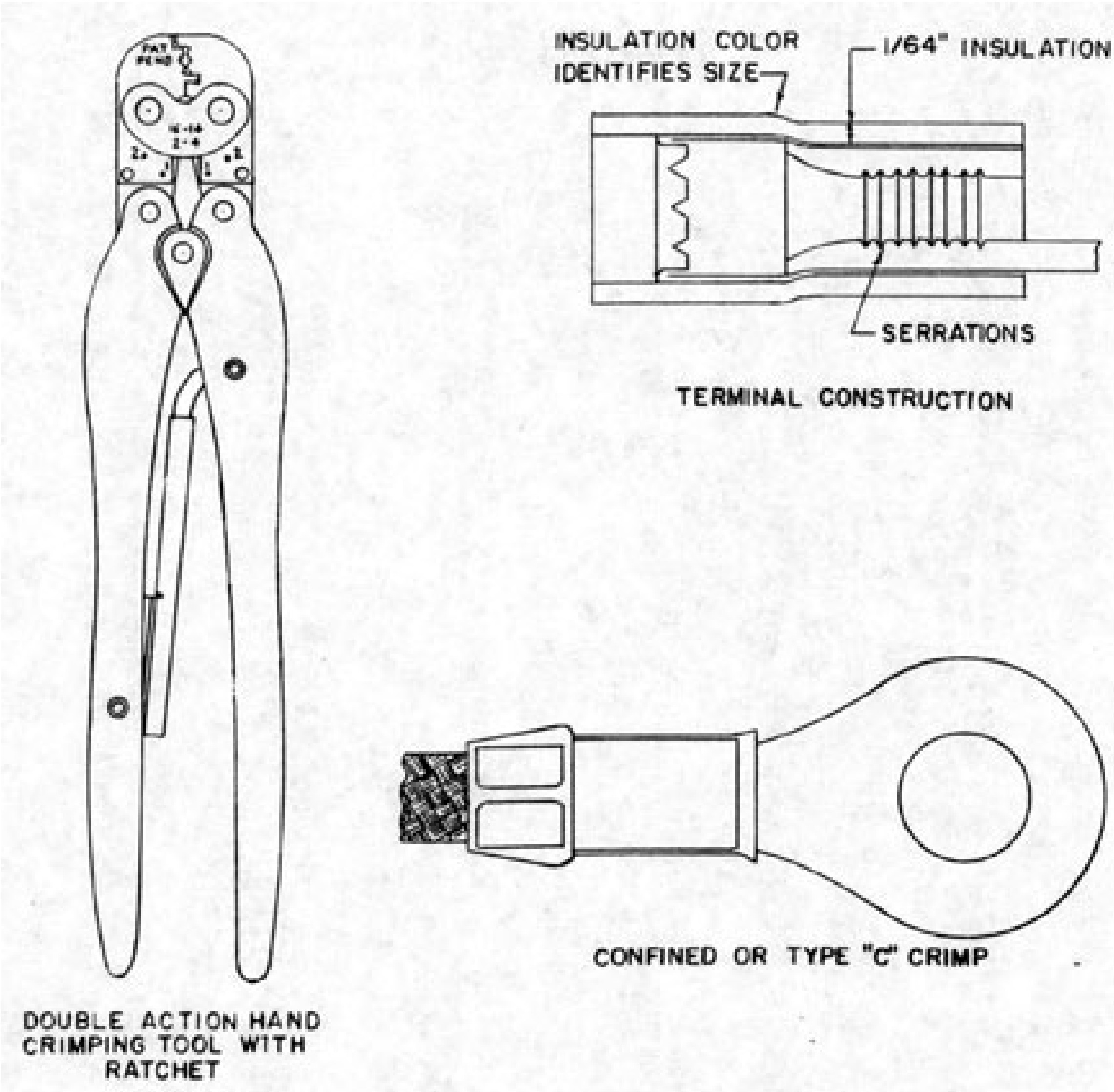



FIGURE 9-54
FEATURES OF AIRCRAFT MARINE PRODUCTS
SOLDERLESS TERMINAL

6. TESTS AFTER INSTALLATION.

When a wiring installation is completed, tests for continuity, shorts and ground should be made. Some of the methods used are as follows:

a. TELEPHONE HEADSETS. -Either sound-powered or battery-powered telephones may be used for this test. When using sound-powered phones, care must be used to avoid capacitive coupling or cross talk in multi-conductor cables, thus giving false indications. The use of battery-powered phones eliminates the risk of cross talk.

(1) TEST FOR CONTINUITY. -Two headsets and two men are required, one at each end of the cable. Ground one lead on each headset. The remaining lead on headset number 1 is connected to a preselected, color coded conductor in the cable. The free lead of headset number 2 is also connected to the preselected, color coded conductor at the other end of the cable. A click will be heard in the phones if there is continuity and conversation can be made over the phones. After establishing continuity, another conductor is selected and the test is repeated until all the conductors are checked.

One man may perform this test by twisting the paired conductors together at one end and touching each of the paired conductors at the other end with the phone tips.

(2) TEST FOR SHORTED CONDUCTORS. -One lead of headset number 1 is grounded, the other is left on the conductor as in the previous test. One lead of headset number 2 is grounded and the other shifted among the various conductors surrounding the one to which headset number 1 is connected. A click in the headphones indicates a short.

(3) TEST FOR GROUNDED CONDUCTORS. -Ground one phone lead to the metal sheath of the cable and touch all the conductors of that cable with the other lead. An indication of continuity indicates a grounded conductor.

b. LAMP OR BUZZER AND BATTERY-The lamp or buzzer and battery may be used by one man to perform these same tests. The conductors at one end are twisted into pairs according to color code and the lamp or buzzer and battery are connected at the other end to the same two conductors.

(1) TEST FOR CONTINUITY. -With the two leads of the lamp or buzzer and battery connected to a pair of conductor s twisted at the other end, continuity is indicated by lighting of the lamp or sounding of the buzzer. Repeat this for each pair of conductors.

(2) TEST FOR SHORTED CONDUCTORS. -Remove one lamp lead and touch that lead to all the other conductors surrounding the pair. A short is indicated by lighting of the lamp. Repeat for each pair of conductors.

(3) TEST FOR GROUNDED CONDUCTORS. -With one lead from the lamp and battery circuit connected to the metal sheath of the cable, touch all the conductors with the other lead. Lighting of the lamp indicates a grounded conductor. If the conductors are left in twisted pairs, untwist the faulty pair to find which conductor is grounded.

c. THE MEGOHMMETER. -The megohmmeter or megger is an ohmmeter which reads in megohms (one million ohms). Tests performed with the megger are set up as described for the lamp or buzzer and battery method. Continuity is indicated by a zero resistance reading.

**9-92**

For testing insulation resistance use a megger having a 0-100 megohm range with a 500 volt D C source, constant voltage.

Figure 9-55 shows typical methods of measuring insulation resistance of cable circuits. The following are the minimum requirements for cables.

POWER: One megohm from each leg or each phase lead of a circuit to ground.

I.C. and F.C.: .2 Megohms or greater for each conductor to ground (During the measurements the megger is connected from one conductor to ground; the other conductors are ungrounded and the circuit de-energized by operation of the supply switch at the power source).

**9-93**

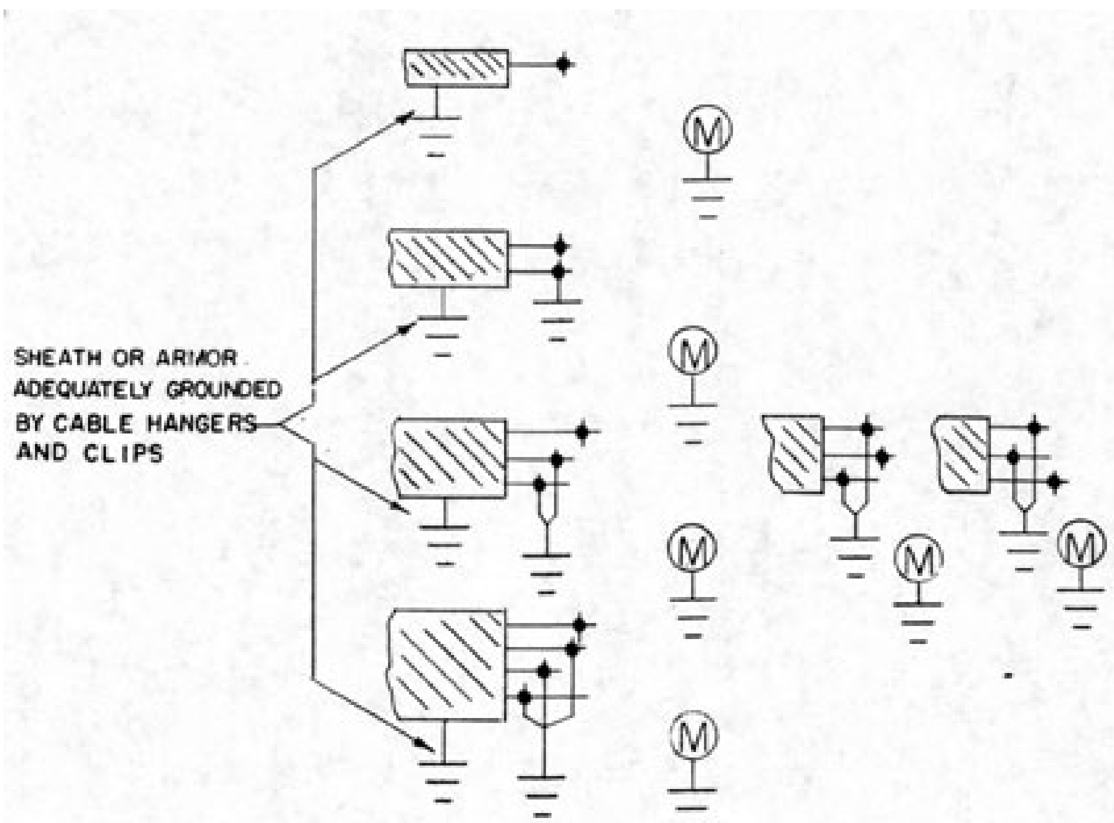



FIGURE 9-55
TYPICAL METHODS OF MEASURING INSULATION RESISTANCE OF CABLE CIRCUIT

7. SPECIAL CABLE CONSIDERATIONS.

When coaxial cable transmission lines are passed through a W. T. bulkhead through a gland which exerts considerable pressure on the cable, after it is adjusted for maximum watertight security, the pressure deforms the cable and changes the spacing between the inner and outer conductors of the cable, thus altering the electrical characteristics of the line. This problem has become very serious in submarine applications where stuffing tubes must be pressure-proof.

TTRSA cable can be utilized to save drilling operations, space and fittings when several coaxial cables leave an equipment and must pass through a bulkhead.

Figure 9-56 shows the method of utilizing TTRSA cable to carry coax loads through pressure-proof fittings. The coax feeds from the equipment to a 10 connector box, where a connection is made to the TTRSA cable.

The TTRSA is then run through all the pressure-proof fittings and terminates in another 10 connector box, where connection to equipment is made through coax. For this application it is important that one lead be left floating to insure constant impedance with frequency. Maintain continuity of the inner shields in the junction boxes.

TTRSA cable has a characteristic impedance of approximately 76 ohms. It has been used in this application in lengths up to 30 feet, with no appreciable attenuation in signal. Some applications are 60 mc IF, sync. signals, trans. pulse, video, etc.

Figure 9-57 shows an approved method of finishing ends of shielded pairs of TTRSA cables.

Installation workers experienced difficulty in soldering a ground lead to the shield. The insulation was easily damaged by the application of heat. This method involves no soldered connections and eliminates the danger from heat.

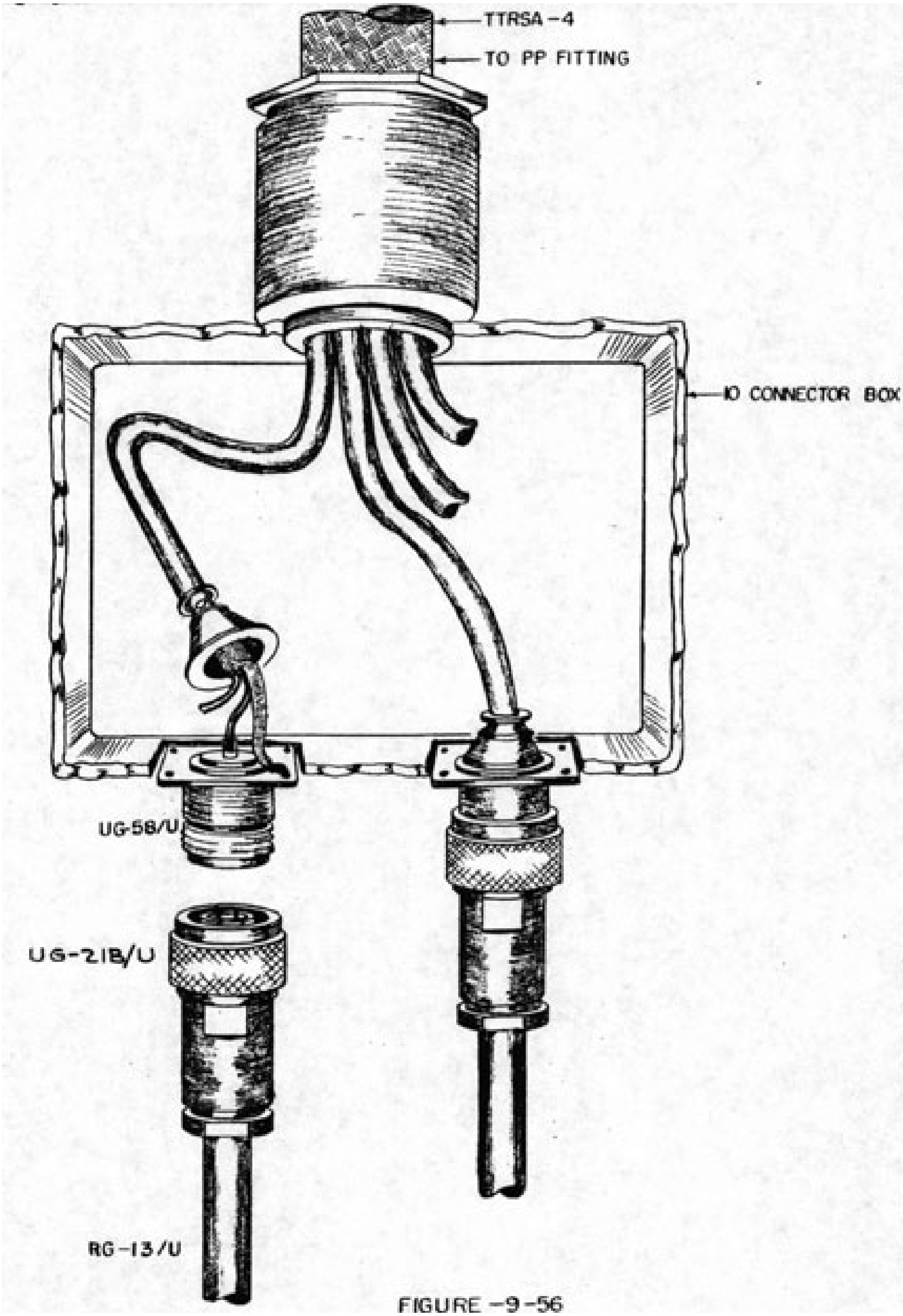
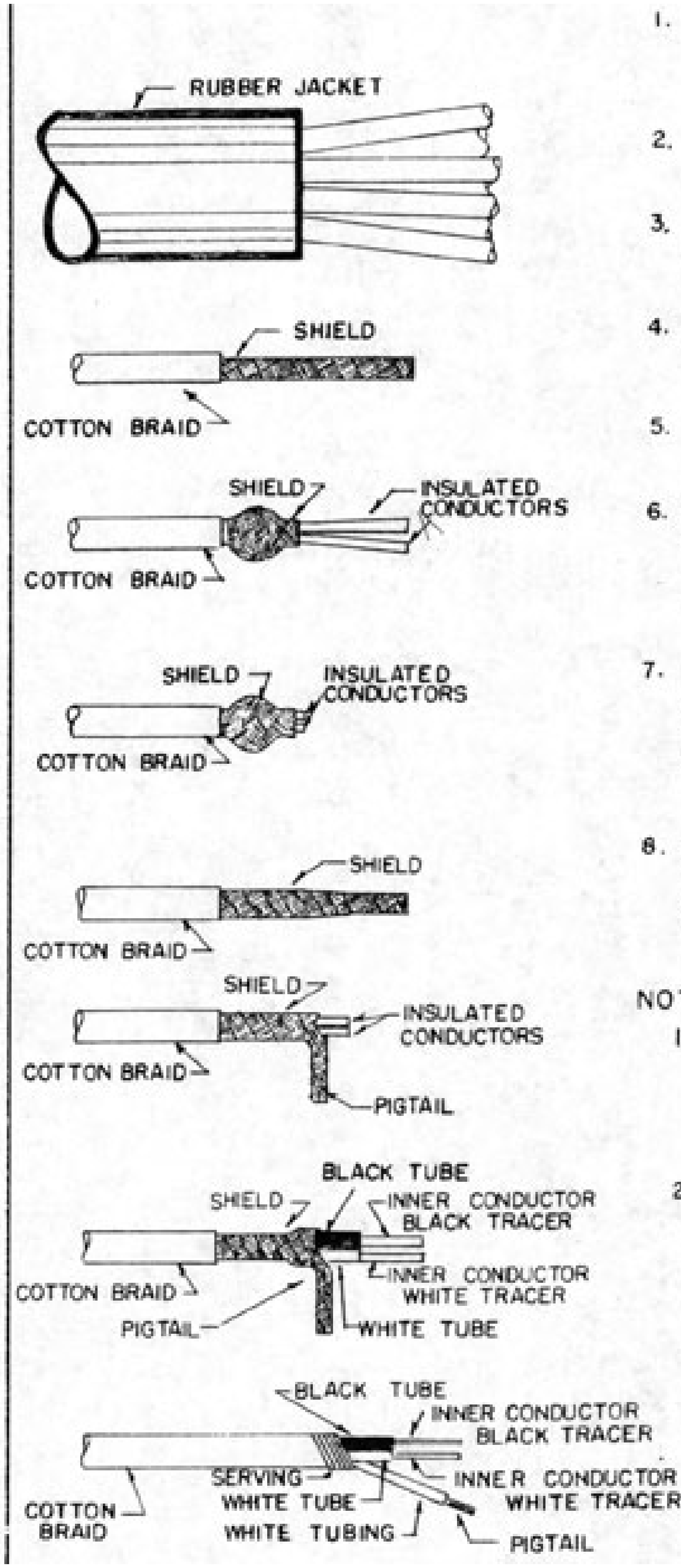



FIGURE 9-56
COAXIAL LINE - TTRSA COUPLER




1. CUT BACK RUBBER JACKET AS REQUIRED.
2. CUT AND PUSH BACK COTTON BRAID ON EACH PAIR.
3. PUSH BACK SHIELD DISTANCE REQUIRED TO OBTAIN DESIRED LENGTH ON PIGTAIL.
4. CUT OFF INSULATED CONDUCTORS EVEN WITH END OF SHIELD.
5. PULL SHIELD FORWARD:
6. SPREAD SHIELD BRAID AT CONDUCTOR ENDS USING A FIBER PICK, ICA CAT. 1039 OR EGUIVALENT, AND WORK CONDUCTORS THROUGH HOLE.
7. PUSH SHIELD BACK TO EXPOSE CONDUCTORS. SLIP BLACK AND WHITE TUBING OVER INNER CONDUCTORS AND INSERT IN SHIELD.
8. SLIP WHITE TUBING OVER PIGTAIL. PULL COTTON BRAID TO JOINT AND SERVE AT JOINT.

NOTES;

1. LENGTH OF CONDUCTORS PROTRUDING FROM SHIELD SHOULD BE AS SHORT AS PRACTICABLE, AND SHOULD NOT EXCEED 3 INCHES.
2. CABLE TYPE TTRS WAS FORMERLY DESIGNATED TTHFFS, AND CABLE TYPE TTRSA WAS DESIGNATED TTHFAS.

FIGURE 9-57
NAVY TYPE TTRS AND TTRSA CABLES-METHOD

OF FINISHING ENDS OF SHIELDED PAIRS

**9-97**

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Previous Part    Cabling Home Page    Next Part

# SECTION 7

# LACING AND BINDING

## 1. INTRODUCTION.

Good workmanship shows up in lacing and binding done with the skill and neatness that prove pride in workmanship. This is one place where you can't count on a coat of paint to hide a poor job.

## 2. PURPOSE OF LACING AND BINDING.

Conductors within an equipment, panel box, or junction box need to be kept in place; otherwise the wiring makes a maze that is not only untidy, but is hard to trace and confusing when changes or repairs are needed. When the conductors are properly laced, they support each other and make a single, neat cable.

## 3. METHODS.

When a cable is laced, the individual conductors should be laid straight and. parallel to each other; they should not be twisted together. Straight cabling makes a smooth job in which each conductor can be traced; twisted wiring makes a lumpy, rough-looking cable in which wires cannot be traced.

## 4. LACING MATERIALS.

A waxed cord, called lacing cord, is used for binding the conductors. The cord comes in two sizes; #6 is used for small or medium sized cables, #8 is used for larger cables.

A shuttle on which the lacing cord can be wound makes it easier to handle the cord. The construction of such a shuttle is shown in Figure 9-58. It may be made of aluminum, brass, fiber, or plastic; steel is not recommended because of rusting.

## 5. LENGTH OF CORD.

The amount of cord needed to lace a cable is about 2 1/2 times the length of the cable run, if single cord is to be used, or about 5 times if double cord is to be used.

## 6. SPARES.

Always serve spares separately and secure to actives with a few telephone hitches to avoid complete re-lacing in the event spares are utilized.

## 7. STARTING.

If the shuttle is to be used, wind on enough cord to fill it. Cord for double lacing should be spooled off and doubled before winding into the shuttle; start the two loose ends onto the shuttle first so as to leave a loop at the starting end.

In starting a lace, a telephone hitch, Figure 9-59, square knot, Figure 9-60 or lock stitch, Figure 9-61 may be used. Note that when the telephone hitch is used, at least two hitches should be made at the start, and when the lock stitch is used, wrap 10 to 12 turns tightly around cable.

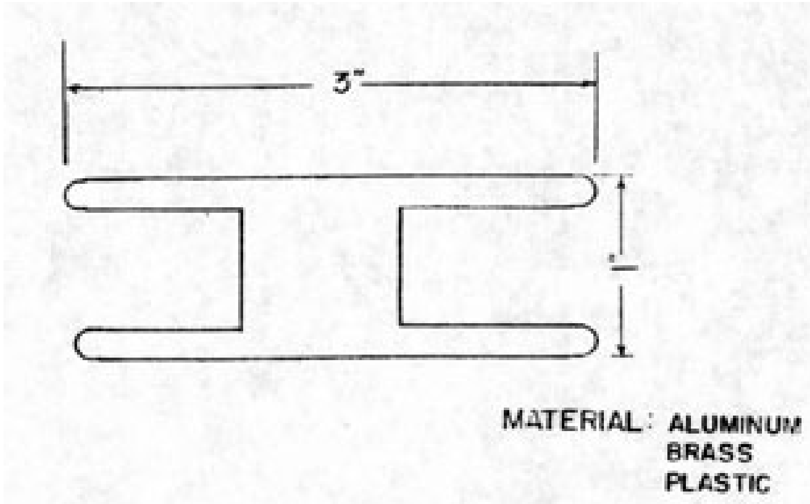


FIGURE 9-58
LACING SHUTTLE

**9-99**

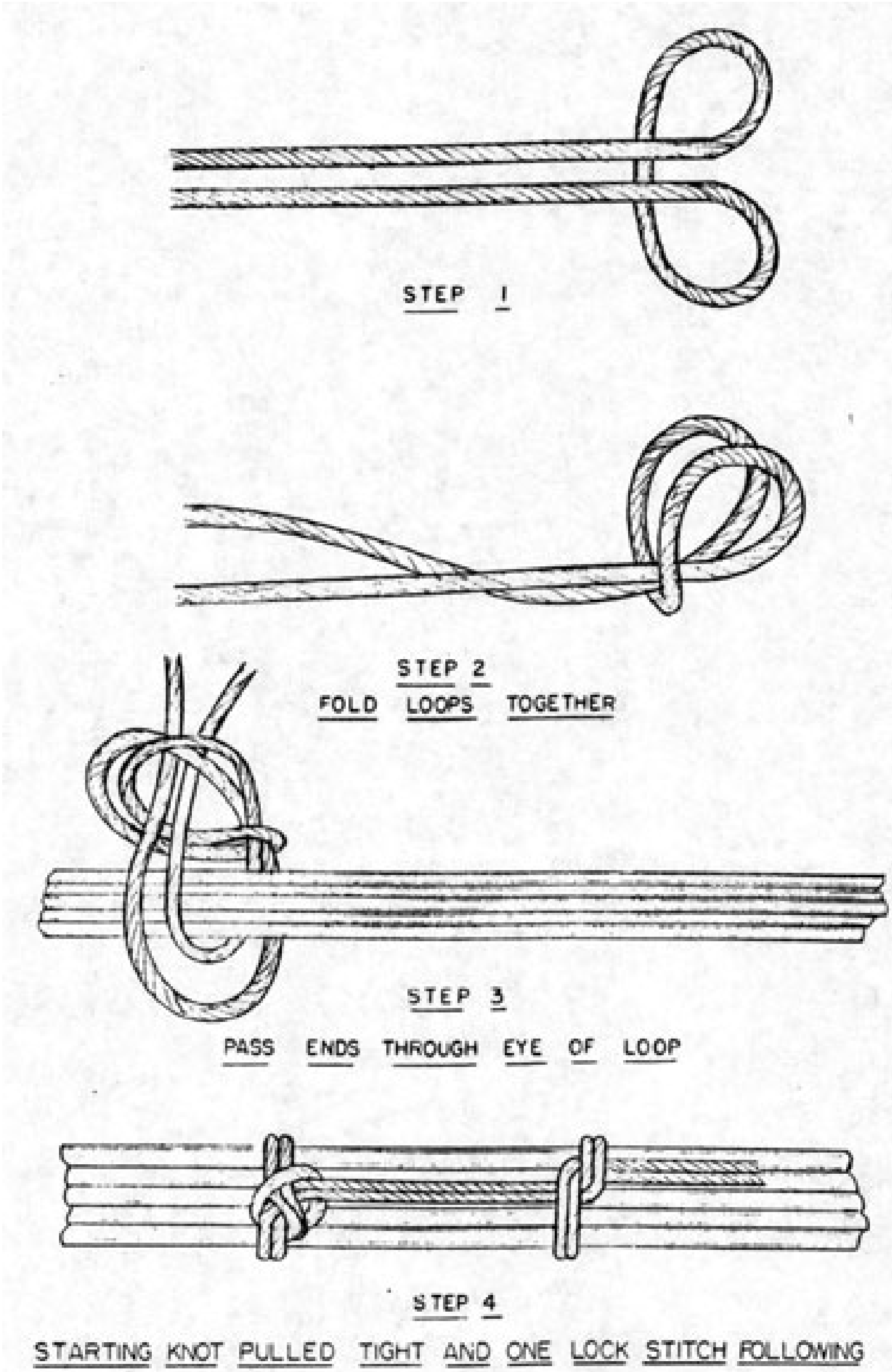


FIGURE 9-59
TELEPHONE HITCH

**9-100**

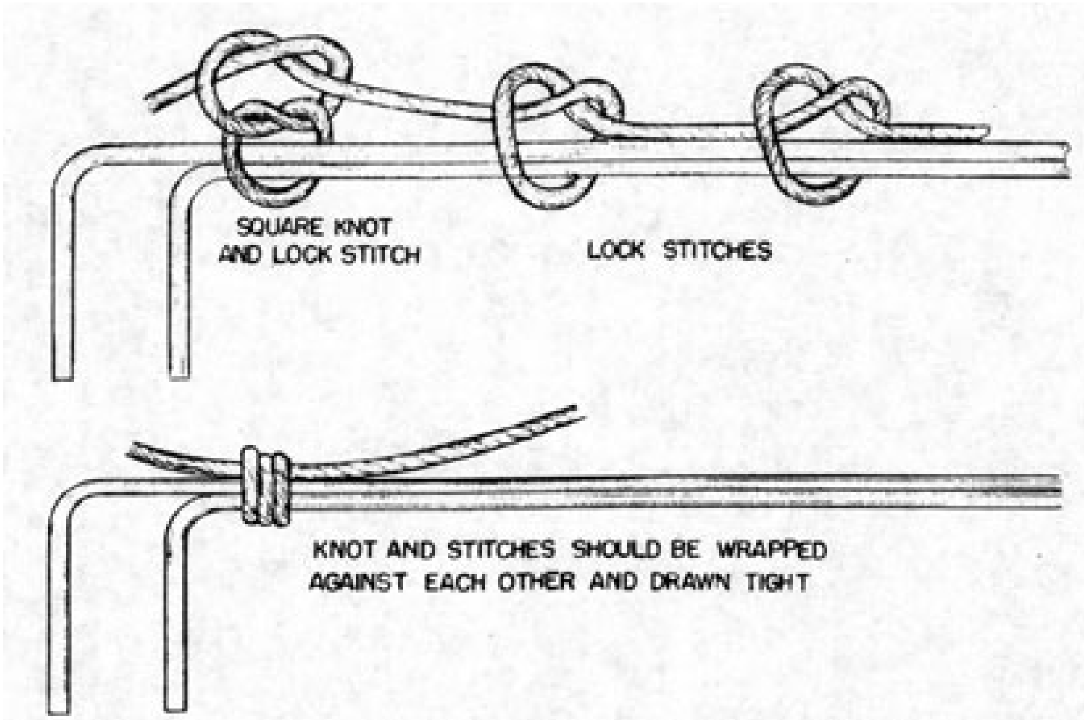


FIGURE 9-60
STARTING THE LACE WITH A SQUARE KNOT AND TWO LOCK STITCHES

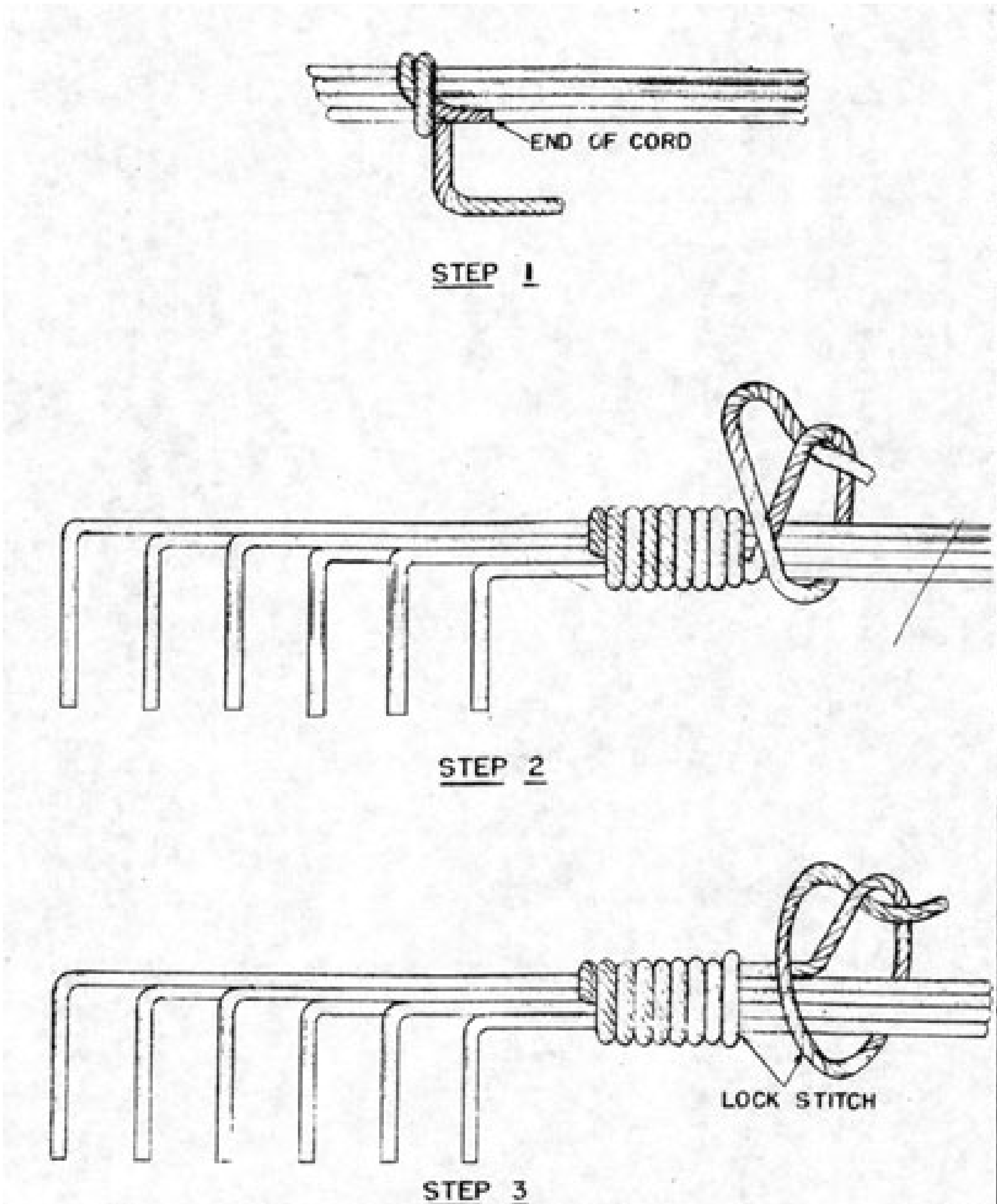


FIGURE 9-61
STARTING A LACE WITH A LOCK STITCH

**9-102**

## 8. LACING.

The stitch used in keeping the conductors together under pressure is the lock stitch. Between lock stitches, a running stitch Figure 9-62 is used at approximately 1/2 inch intervals. The running stitch is kept parallel to the conductors in the cable and should not be wound around it. The lock stitch keeps the running stitch pressed against the cable.

The details of the lock stitch are shown in Figure 9-61; the manner in which the lock stitch is made may vary, but the "over and under" form is necessary to prevent unraveling of entire cable lacing, in the event one or more stitches are cut.

## 9. BREAKOUTS.

When breakouts occur (Figure 9 -63) always double lock stitch before the breakout, then continue on for single breakouts.

When a cable divides into two or more smaller cables, wrap several turns at the dividing point; Figure 9-64, make a lock stitch and continue lacing one of the branches. The other branch may be started as a new run. When only one conductor is branched out from the main cable, it is branched at a double lock stitch without any variation in distance between lock stitches

If the branch has two or more conductors it should be laced.

## 10. BENDS.

When bends occur in cable runs, always make the bend before lacing, to keep the bend in place (Figure 9-65).

## 11. AN ALTERNATE METHOD.

Figure 9-66, consists of a series of individual bindings along the cable run. A piece of cord about 2 inches longer than that required to make 12 turns around the cable will give the correct length. Wind 10 to 12 turns tightly over a 1 inch loop. At the last turn, push the end of the lacing cord through the loop which extends under the binding. Pull loose end under binding. Repeat as often as required.

## 11. TERMINATION.

The termination of a lacing may be made by 3 or 4 lock stitches together tied down with an overhand knot or as shown in Figure 9-67.

## 12. TWO OR MORE CABLES.

When two or more multi-conductor cables enter an enclosure it is good practice to lace each cable group separately, so that tracing conductors back by color coding will not be confusing and to use cable replacement. Where two or more groups run along together, the laced groups may be secured to each other with a few telephone hitches (Figure 9-68).

**9-103**

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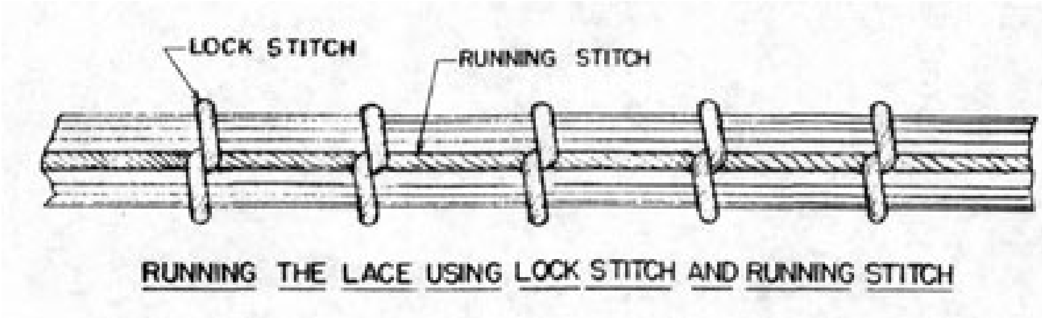


FIGURE 9-62
RUNNING THE LACE

**9-104**

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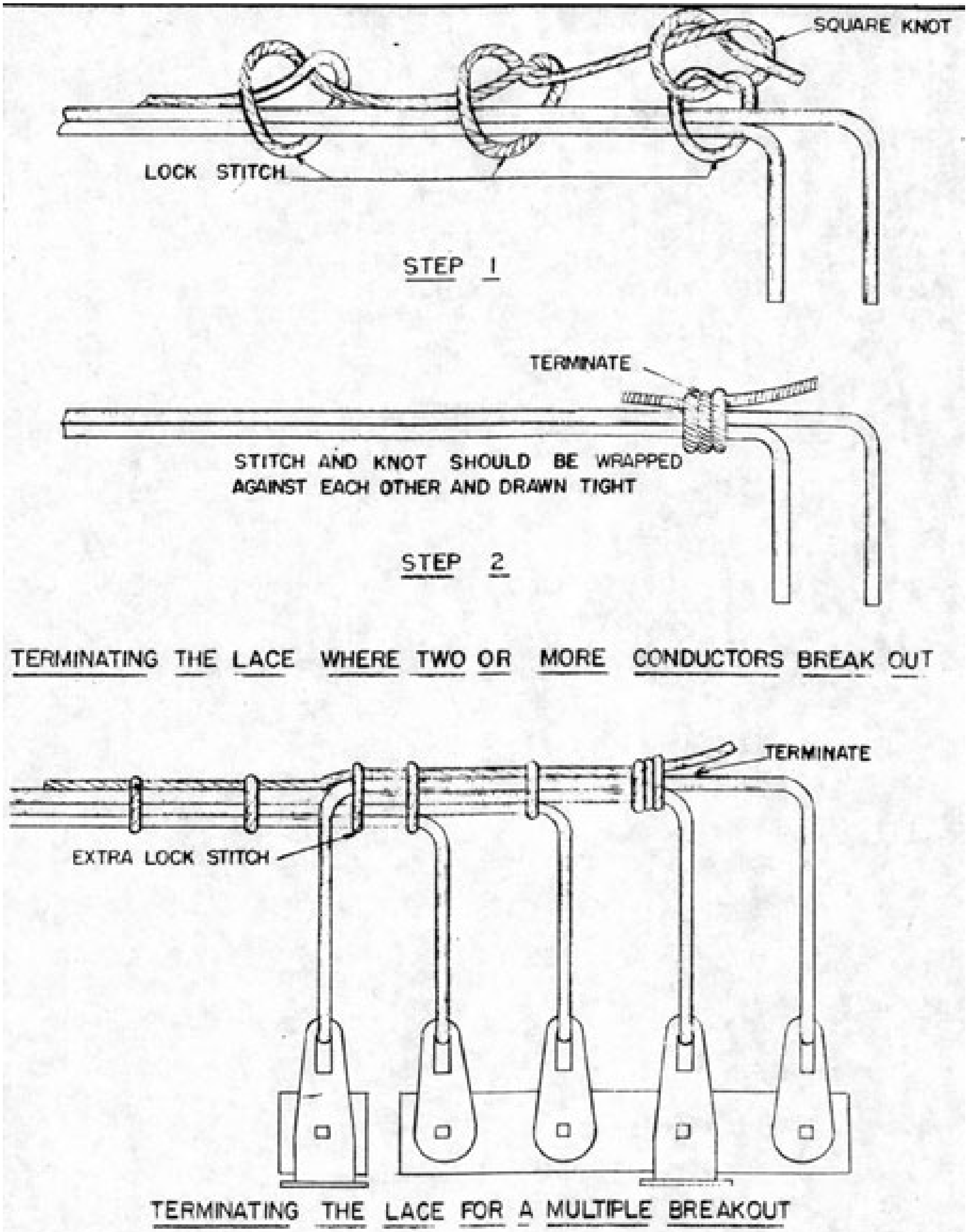


FIGURE 9-63
METHOD OF LACING AT BREAKOUTS

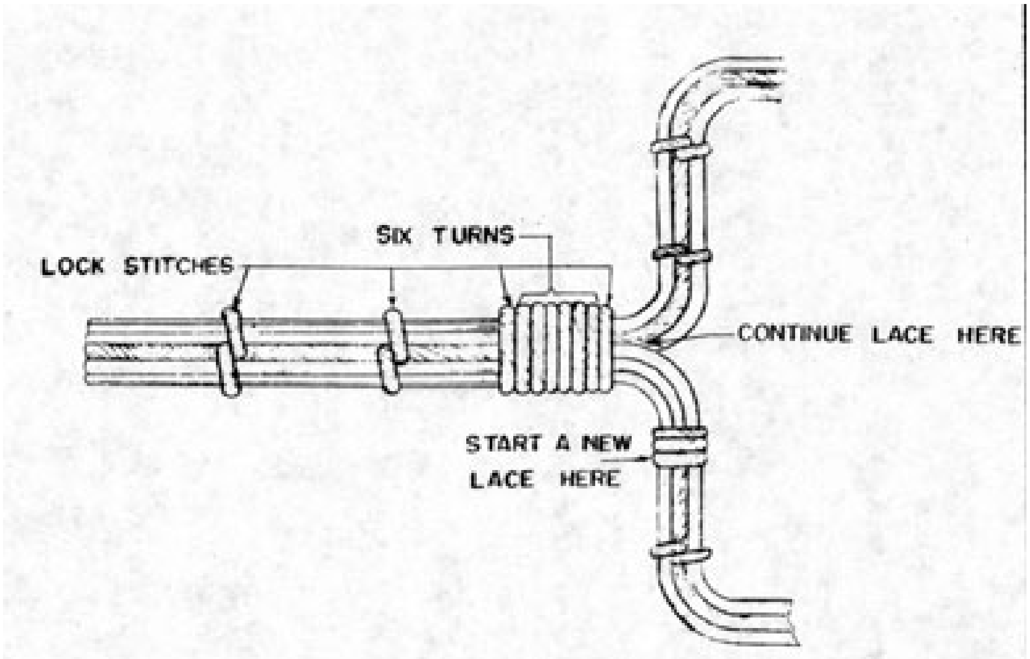


FIGURE 9-64
METHOD OF LACING WHERE CABLES DIVIDE INTO BRANCHES

**9-106**

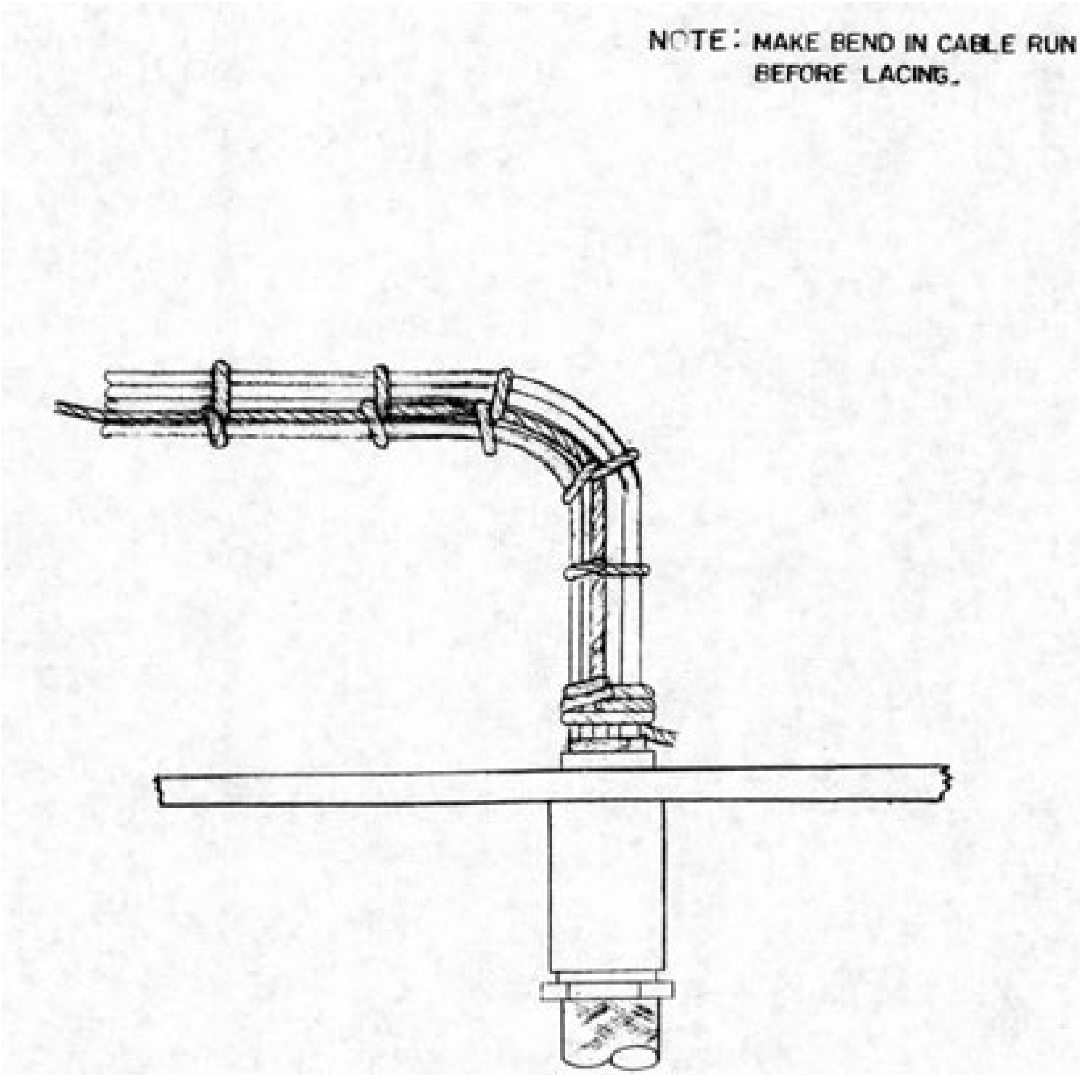


FIGURE 9-65
METHOD OF LACING AT A BEND

**9-107**

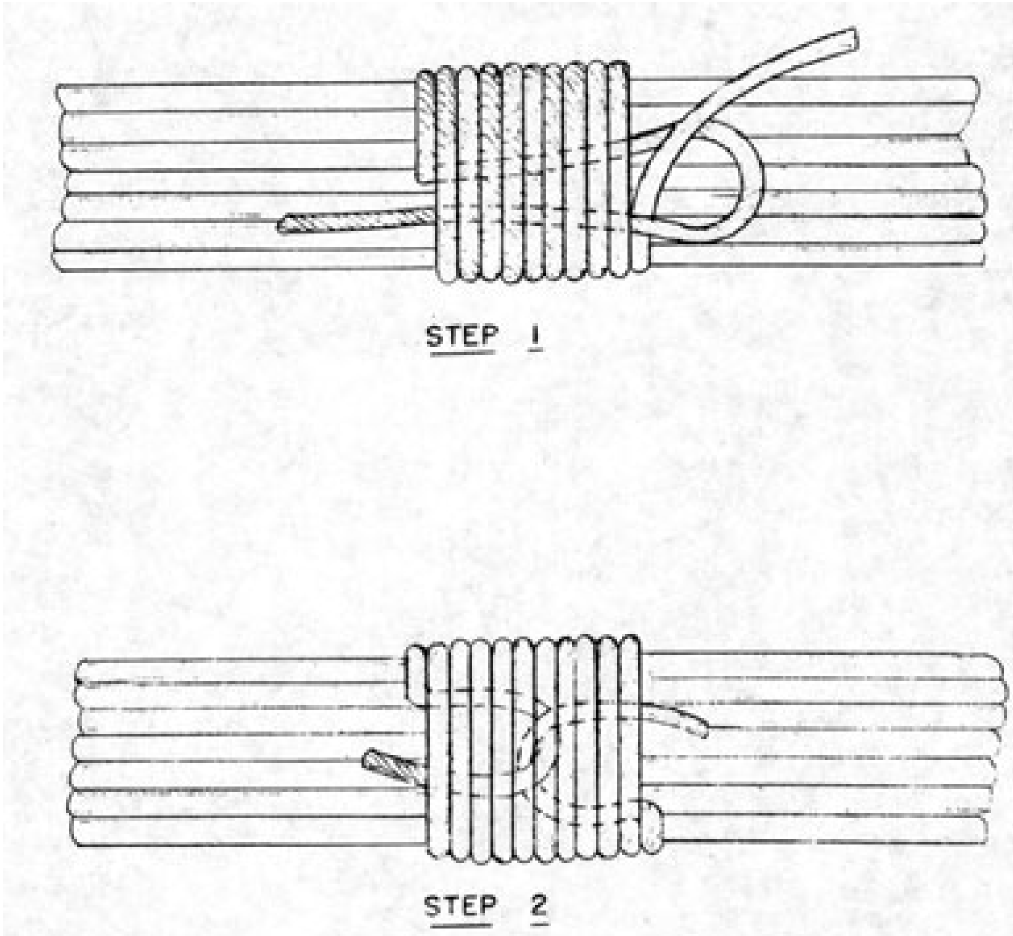


FIGURE 9-66
METHOD OF LACING CABLES USING INDIVIDUAL BINDINGS

**9-108**

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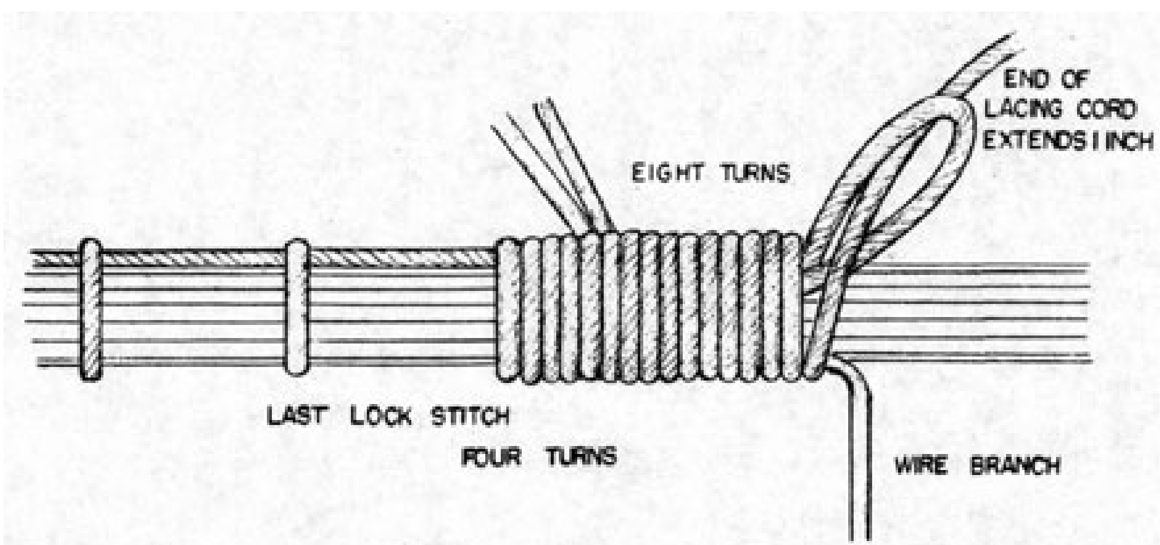


FIGURE 9-67
METHOD OF TERMINATING THE LACE

**9-109**

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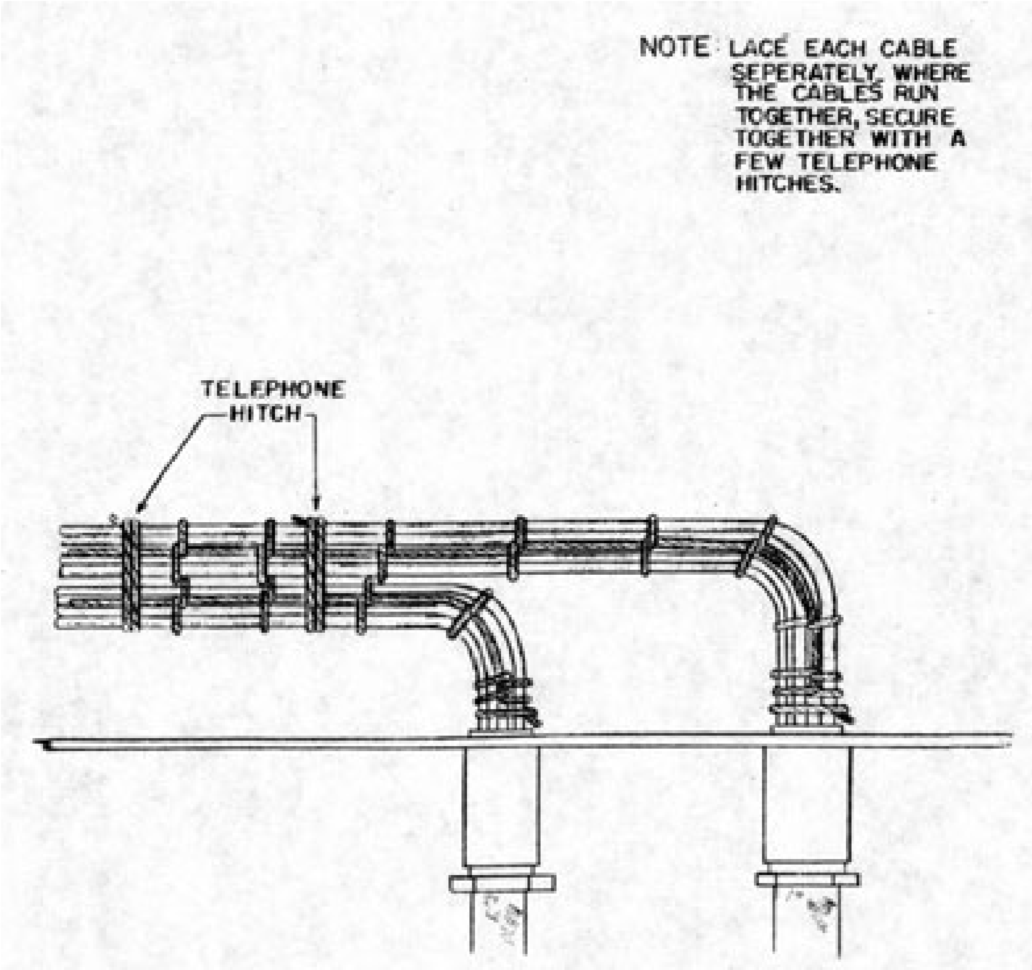


FIGURE 9-68
METHOD OF LACING WHERE TWO OR MORE CABLES RUN TOGETHER

**9-110**

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Commando Boat *Krait*, Sydney, New South Wales
*MB172 Epiclass*, Sydney, New South Wales
HMAS *Onslow*, Sydney, New South Wales
HMAS *Vampire*, Sydney, New South Wales

HMAS *Whyalla*, Whyalla, South Australia

**CANADA**

RV *Ben Franklin*, Vancouver, British Columbia
RCMPV *St. Roch*, Vancouver, British Columbia
HMCS *Fraser*, Bridgewater, Nova Scotia
HMCS *Sackville*, Halifax, Nova Scotia
HMCS *Haida*, Hamilton, Ontario

**ENGLAND**

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**FRANCE**

FS *Colbert*, Bordeaux

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**SWEDEN**

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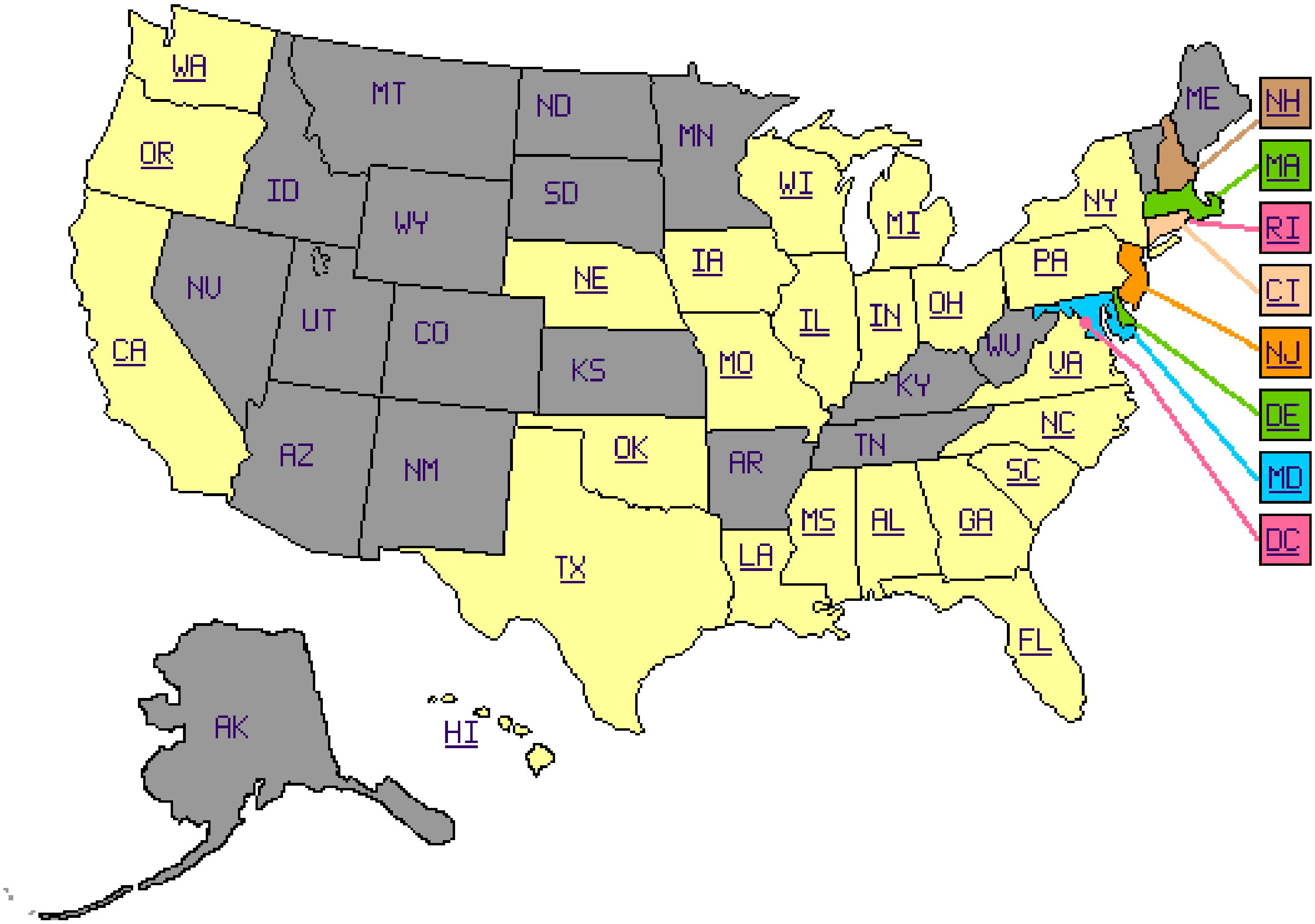
**UNITED STATES OF AMERICA**

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Steam Yacht *Medea*, San Diego, California
USS *Midway*, San Diego, California
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Japanese *Kaiten*, Hackensack, New Jersey
USS *Ling*, Hackensack, New Jersey
*PBR Mark II*, Hackensack, New Jersey
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*Fenian Ram*, Paterson, New Jersey
*Holland Boat #1*, Paterson, New Jersey
*Intelligent Whale*, Sea Girt, New Jersey

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USS *The Sullivans*, Buffalo, New York
MV *Commander*, Cornwall-on-Hudson, New York
USS *Growler*, New York, New York
USS *Intrepid*, New York, New York
USAT *LT-5*, Oswego, New York

Admiral's Barge, Romulus, New York

**North Carolina**

USS *North Carolina*, Wilmington, North Carolina

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USS *Cod*, Cleveland, Ohio

SS *William G. Mather*, Cleveland, Ohio

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USS *Batfish*, Muskogee, Oklahoma

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USS *Blueback*, Portland, Oregon

*PT-658*, Portland, Oregon

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U.S. Brig *Niagara*, Erie, Pennsylvania

USS *Becuna*, Philadelphia, Pennsylvania

USS *Olympia*, Philadelphia, Pennsylvania

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USCGC *Ingham*, Mount Pleasant, South Carolina

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**Texas**

USS *Lexington*, Corpus Christi, Texas

Admiral's Barge, Fredericksburg, Texas

Japanese *HA-19*, Fredericksburg, Texas

*PT 309*, Fredericksburg, Texas

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Version 2.24, 28 Mar 06

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